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ABSTRACT

Governmental, business and scientific activities have been placing and will continue to place heavy reliance on data processing equipment and procedures. Because of increasing complexity and speed of equipment and sophistication in procedures, utilization of this powerful tool is highly dependent upon the quality of management of the data processing operation. Management of this function depends to a great extent on several major factors. This paper describes and examines five key elements of successful data processing management--organization, personnel, documentation, control, and standards.

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CHAPTER I

INTRODUCTION

In recent years, much has been written about conducting feasibility studies, advances in programming languages and techniques, selecting proper data processing equipment, and technical matters of interest to the analyst, programmer and engineer. Conversely, very little has been written about managing the data processing operation despite the fact that success of this operation is vitally dependent upon efficient management.

Outside the data processing field, relatively little is known about the best type of organization, technical personnel requirements, performance standards to be expected, extent of documentation required, and the types of controls to be employed. Thus, the data processing manager often becomes a supervisor with much broader responsibilities than normally assigned to other supervisors at the same organizational level. He frequently must determine his own organization pattern, perform a considerable amount of his own personnel administration, develop his own performance standards, determine his own documentation requirements, and establish his own controls.

This paper concerns five key elements of data processing management--organization, personnel, documentation, control,

and standards. Chapter II contains an examination of alternate locations for the data processing activity in the overall organization structure and alternate internal organization patterns of the data processing operation itself. A discussion of the data processing personnel problem as viewed by management and recommendations for its solution are contained in Chapter III.

Chapter IV describes documentation requirements for programs, the Run Manual, the Console Run Book, and the General Procedures Manual. Financial and budgetary controls, operating controls, internal controls and the basic requirements for establishing an audit trail are also discussed in this Chapter. Primary functional areas to which standards must be applied for effective management control are examined in Chapter V. The generalized summary and conclusions of this paper are presented in Chapter VI.

CHAPTER II

ORGANIZATION

In most organizations, the objective of the data processing system is to integrate the processing of data across organizational lines. This creates unique relationships between the data processing function and other units of the organization. In addition, the data processing organization itself is an unusual combination of stringent operating detail and creative development work. Thus management of this function requires a blending of technical and managerial skills. To further complicate data processing organization, the question of direction of the programming effort often arises. Frequently, awareness of the potential of high speed computers is closely followed by a proposal to decentralize programming so that unit projects can be programmed under direct unit supervision.

This chapter examines the position of the data processing operation in the organization structure, internal organization of the data processing operation itself, and open shop versus closed shop programming.

I. LOCATION IN THE ORGANIZATION STRUCTURE

The position of the data processing center in the organizational structure depends to a great extent on the scope of the work which the center is expected to undertake. If the computer is expected to contribute to all areas of an enter-

prise, it must be organizationally located to do so. This location must be in a position to obtain the support and cooperation of the entire organization being served. In some organizations such a location may require reporting to vice-presidential level; and in others, a considerably different reporting level. In any case, the data processing center must be in such a position that its performance can be accurately appraised and its contributions to overall organization objectives evaluated.

In a recent survey of some 27 companies in 13 different industries, McKinsey and Company, Inc. determined that nine companies were decidedly successful in their computer use.[1] Success was measured on the basis of dollar return earned from computer system investment, intangible benefits received, and the range and scope of applications currently installed on the computer. In all the lead companies and in two-thirds of the remaining companies, the computer executive (i.e. the executive to whom the computer systems manager reports) was no more than two levels below the chief executive. At the bureau or agency level within the federal government, the most common organization pattern is to establish the ADP function on a par with other primary management functions of

[1] John T. Garrity, "Top Management and Computer Profits," Harvard Business Review, July-August 1963, p. 10.

the agency.[2] For example, in those bureaus and agencies in which there is a deputy or assistant chief for management, the data processing function ranks along with the fiscal, personnel, budget and other management functions which are considered highly important in achieving overall management effectiveness.

The following three possible organization locations are examined in further detail:[3]

1. An integral part of a single major department, performing relatively minor services for other departments,

2. A separate unit servicing several major departments largely along the lines established or approved by those departments, or

3. A relatively independent department which has approximately equal status with those other departments with which it is integrated in the processing of the paper work.

Advantages and disadvantages of the alternate organizational locations,as well as a conclusion on optimal location, are contained in the following paragraphs.

[2] The Graduate School, U. S. Department of Agriculture, Automatic Data Processing Seminar for Federal Executives: 1961. (Washington: The Graduate School, U. S. Department of Agriculture, 1961), p. 193.

[3] B. Conway, J. Gibbons, and D. E. Watts, Business Experience with Electronic Computers (New York: Controllers Institute Research Foundation, Inc., 1959), p. 144.

As An Integral Part of a Major Department

This method of placement results in minimum disruption of the organizational structure. The most prevalent example of this type location is to assign the ADP function to the Comptroller. In many instances of this nature, ADP equipment is used as a form of departmental mechanization, as bigger, better and faster tabulating equipment. Another example is where the data processing function is largely statistical or scientific in nature as contrasted to the business management data processing type of activity. In this case, the ADP function is sometimes merged with regular operating responsibilities.

No major organizational problems appear to arise in this type of organizational location, so long as one major department is, in fact, the major user of computer services. However, when several major departments require a great deal of computer work, a decision must be made as to whether to continue operations according to this concept and thus possibly establish separate ADP units within the several major departments or whether to choose one of the two alternatives discussed later.

If ADP is to be left under the Comptroller and a decision made to expand use of the computer into the field of operating decisions, the difference between the accountant's concept of control and the operating man's concept must be faced and

resolved. These two concepts have been defined by L. R. Fiock, Jr. as:[4]

> To an operating man, control is the analytical processes which lead to (1) decisions as to future courses of action, and (2) routine decisions which control the function within the plan.
>
> In the parlance of the controller's personnel, control is surveillance of after-the-fact summations, usually compared to historical norms.

Under conditions of expanding computer use into operational areas, with the computer organizationally placed under a major using department, it may be necessary for effective operation and utilization to establish an ADP project director or coordinator reporting to an executive on a level higher than that of the departments involved. His functions would be to plan, make day to day decisions, resolve jurisdictional disputes, and to keep the chief executive advised on progress.

The case against separate ADP centers for other major departments is essentially an economic one. An equivalent amount of money spent to operate multiple centers will not normally buy as much computing ability as will a single center. In addition, extra floor space and other installation requirements, the need for additional operating crews,and the inability to achieve a break-even operation as quickly with multiple machine centers,all work against this approach.

[4] L. R. Fiock, Jr., "Seven Deadly Dangers in EDP," Harvard Business Review, May-June 1962, p. 94.

Thus, in this type of organizational location, unless the major department is the major user, administrative and/or economic problems will accompany expansion of computer use in additional areas of application.

As A Service Center

In an organization where there are several major departmental users of the computer, the data processing function is sometimes established as a service center to serve all departments. There are many variations of this organizational concept, ranging from the center which reports directly to one of the major users but has a charter stressing its interdepartmental nature, to the center which operates by having each department do its own development work and supply its own operational staff.

Normally, the service center approach does not interfere with the existing organization structure on the departmental level, except in those instances when the computer center reports to the major using department. The service center, per se, is not intended to move functions or responsibilities from one department to another. The manager of each functional area uses the computer at his own discretion for specific phases of his function.

In actual practice under the service center approach, top management's direct interest is usually limited to selecting equipment, and to reviewing rental or procurement costs.

By way of contrast, McKinsey & Company, Inc., in its survey found that in the lead companies, top management had much broader interest in the data processing function and devoted considerable time to the computer systems effort, to reviewing plans and to follow-up on computer system results.[5] And as a result of top management interest, operating management was more highly involved in project selection and planning in the lead companies than in the others. With the service center approach, the incentive for top management and operating management participation, a factor for successful computer use, is more likely to be minimized.

The policies which are incorporated into computer programs to control organization action documents (purchase orders, requisitions, job orders, personnel actions, etc.) may also be used in simulation programs for predictions. The ability to use control policies in simulation programs has yielded tremendous improvements and has vast potential in all forecasting and prediction activities. In addition to the simulation of established policies for prediction purposes, various proposed policy alternatives can be simulated to show probable future conditions under various choices. It is in this area that the service approach exhibits its greatest weakness. The scattered, independent computer jobs are not readily adaptable to support a valid policy simulation.

[5] Garrity, op.cit., pp. 8-12.

Thus, if the maximum benefit to an organization both in terms of full exploitation of an integrated data processing system and realization of the current and potential advantages of simulation are desired, the service center concept will not yield maximum results. The greatest danger in the service center approach is the expenditure for ADP equipment which is utilized in continuing the previous mode of operation--to quickly handle little problems rather than to more efficiently and expeditiously handle the total organization problem.

As A Relatively Independent Unit

The data processing function can also be established as a relatively independent major department whose function and responsibility become one of processing data from raw to final form according to the rules, policies and practices of the organization. In this case, for example, the data processing center would be responsible for taking approved input data from a department such as financial, and producing required information for the financial, production control, purchasing and other departments.

This type placement causes most disruption in organizational lines of authority and in assignment of responsibility. It encounters the greatest resistance from middle managers who visualize that the ready availability of all data may tempt top management to make decisions without turning to them for an explanation.

On the other hand, centralization of record keeping is one of the primary bases for economical utilization of data processing equipment. Establishment of the data processing function as a separate entity enhances the perspective necessary to formulate a company-wide data processing system. Programs can then be developed crossing departmental lines. Expansion of computer use beyond the payroll, accounting, inventory control, and other similar functions to the more sophisticated techniques of operations research and simulation will be more likely. And the incentive for top management and operating management involvement with the computer effort will be maximized. High level support of and continued guidance for the data processing function is vital for efficient and economical utilization particularly when initial goals are tempered by reality.

Thus, this type organizational location, although the most disruptive of the three, provides the best alternative for the development of an integrated, automated management system and for the realization of the full potential of the data processing function. According to a survey conducted by System Development Corporation of Santa Monica, California, corporations are moving toward the centralization of computing services.[6] Of the 30 Southern California firms surveyed--

[6] Charles M. Lawson, "A Survey of Computer Facility Management," Datamation, July 1962, p. 30.

which included major aircraft and missile manufacturers, petroleum producers and distributors, insurance and title companies, banking institutions and educational centers--60% indicated that the computer function operated as a separate and distinct entity, such as a data processing department or computer center, with full control and responsibility.

II. ORGANIZATION OF THE DATA PROCESSING CENTER

In determining the type of organization to be utilized for the data processing operation itself, recognition must be given to the necessary functions and to the assignment of responsibility for the performance of each. Poor organization is a source of overlooking important requirements and of frustration for competent personnel.

The basic functions which must be performed in any data processing operation are management, systems analysis, programming, machine operation and clerical and administrative. An additional function, which may or may not be required depending on the maintenance arrangements in effect, is that of maintenance. These functions are examined in further detail in the following paragraphs.

Systems analysis. The systems analysis function encompasses application analysis and systems design. Application analysis is the conduct of studies of organization systems and operations to determine improved methods of processing data involved in these systems and operations. It

includes reviewing information needs and their translation into stated objectives, economic analysis of proposed applications to determine cost justification and to determine their fit into the overall data processing plan, and continuing liaison with operating departments and top management to determine future needs and the effectiveness of current application. Systems design involves the analysis and design of systems which automate applications which have been approved for computerization. It includes gathering data on objectives, current methods, volume, costs, reports, and similar factors pertinent to the application being studied; recording data by means of flow charts, graphs, tables, etc.; analyzing the data to find the best way to meet system needs; determining the economic and administrative effects of the new system; defining and documenting all clerical, control, and equipment procedures of the new system; and selling the new system to all affected segments of the organization.

Programming. The programming function encompasses programming, testing, and documentation. Programming involves designing efficient computer systems from the specifications provided by systems analysis, which minimize programming expense and computer operating time. It includes designing the machine block diagram flow of the program, selecting standard program routines and available programming systems for incorporation, and preparing and coding the necessary

instructions to carry out program logic. Testing includes the design of efficient test methods, selection of appropriate data for a test run, isolation and correction of programming errors using testing aids and software aids, testing the fit of a specific program in the overall data processing system, and final testing using operating data. Documentation involves the reduction of the systems and programs to standardized written form for use in machine operation, training, and in future system and program modification.

Machine operation. The machine operations function involves control of data flowing into and out of the processing equipment and the effective operation of the particular configuration of central processing unit and peripheral equipment necessary to process that data. It includes the actual loading, unloading, setup and control of the equipment comprising a data processing installation.

Clerical and Administrative. This function involves input preparation, input/output control, and maintenance of record libraries. Input preparation consists of preparing accurate, properly coded input data according to schedule and in a manner prescribed by the data processing system. Input/output control includes logging input and output documents, insuring timely input from operating departments, routing of work in accordance with prescribed procedures, short-term scheduling of jobs, output document preparation, control of

supplies, and assembly of files, input and other data before processing begins. Library maintenance involves the control on an item by item basis by means of detailed control records of all data files, programs, documentation, and operating records and reports.

Management. The management function encompasses supervision and administration, planning and project control, development and maintenance of standards, and liaison. Supervision and administration includes optimum utilization of equipment through proper scheduling and control and recruitment and training of personnel. Planning and project control includes long-range planning, budgeting, and familiarization with new developments in hardware, software, and computer techniques. Development and maintenance of standards includes development of a quantity and quality evaluation system based on meaningful standards, determination and publication of job descriptions, and continual review and evaluation of individual and group performance. Liaison involves a constant interchange with operating departments and top management, insuring a smooth timely flow of data, and the translation of technical terms to management terms.

These, then, are the basic functions which must be recognized and accomplished in any data processing operation. How these functions must fit together to best achieve data processing objectives depends on a variety of conditions--what

these objectives are, the size of the installation, quality of personnel, future plans, etc. There is no general answer to every situation. Each organization must be tailored to fit a given situation and the relevant conditions.

Three general patterns of organization for these functions have been suggested by IBM.[7] These are the strictly functional, grouped functional, and the staff/line.

In the strictly functional organization, skills are organized along pure functional lines and management functions are assigned to each of the functional supervisors who report to the data processing manager. An example of this organizational pattern is contained in Appendix I. An organizational structure of this type might serve a less complex, medium-size data processing operation with a relatively stable and predictable workload.

In the grouped functional organization, the operations aspects are separated from the planning and programming aspects with the supervisor of each major group reporting to the data processing manager. An example of this type structure is contained in Appendix II. This type organization is more appropriate for a larger installation with more frequent program changes or an installation expanding into a more complex

[7] International Business Machines. <u>Organizing the Data Processing Installation</u>. IBM form number C20-1622-0. White Plains: International Business Machines, 1961, pp. 13-16.

or closely integrated operation.

The staff/line organization separates the staff functions of management from the line operating functions. An example of the staff/line structure is contained in Appendix III. This type organization is particularly suitable to a large installation which must respond rapidly to changing requirements.

Although no general solution to the data processing organization problem has been developed, IBM has determined several general factors which influence organizational structure.[8]

These are:

<u>Size</u>. Normally, the larger the data processing operation, the greater the number of organizational units and sub-units.

<u>Separation of planning and operating functions</u>. Separation of these two functions is considered necessary for several reasons--planning requires different skills and more training, planning should be "isolated" from the day-to-day pressures to which the operating functions are subjected, and planning requires creativeness whereas operating functions are more disciplined and routine.

<u>Span of control</u>. Span of control should be kept as narrow as possible because of the demanding and technical

[8] Ibid. p. 13.

aspects of the data processing operation. This requires high technical competence in unit managers.

<u>Skill identification</u>. Segregation by skills aids maintaining high level of supervision. Differences between skills such as programming and systems analysis, console operation and programming, and input preparation and console operation must be recognized. Management can best exercise control and optimize output quality when technical personnel report to a supervisor with comparable skill identification.

<u>Grouping</u>. Because of technical and management considerations, the number of technicians reporting to a supervisor should normally be limited to 8 to 15.

<u>Stage of development</u>. The life of a data processing operation tends to evolve from heavy emphasis on planning to some later mix of planning and operations depending on organizational objectives and philosophy.

The best organization for a given data processing operation is dependent upon many factors, some of which have been enumerated above. It is an organization which serves to blend information needs and computer technology most effectively at the least cost. An organization which is neither dominated by procedure-oriented personnel nor computer-oriented personnel, but where each has strong influence on the final decision, is most likely to develop optimum solutions and to operate most effectively.

III. CLOSED SHOP VERSUS OPEN SHOP PROGRAMMING

In the closed shop programming organization, a separate programming group organizationally attached to the data processing center accomplishes the programming function. In the open shop structure,programming is accomplished by the program sponsor.

Closed shop programming is generally the rule in commercial data processing operations. This type programming permits more effective scheduling, greater program efficiency, more efficient integration into the overall data processing system, and better utilization of standard programming routines.

In the scientific installation, many of these factors are not as important, and it is in these installations that the open shop system is more widely used. Many jobs are of a one-time nature and can be programmed very quickly. Normally, such jobs are separate entities and as such do not require integration in overall system design. Program efficiency is not as important because of the program's one-time nature. Interest is usually restricted to one department and thus coordination and communications problems are either small or nonexistent. Open shop programming does present scheduling problems since it is difficult to estimate the machine time required. Additionally, a multiplicity of short programs, per se, complicates development and control

of effective schedules.

In the System Development Corporation survey,[9] it was 3 to 1 in favor of closed shop programming, with general agreement that open shop programming was only relevant to scientific facilities. Sample comments were:[10]

> Open shop programming opens the door for duplication of effort.
>
> We were open shop programming and operations. We closed operations first and do subscribe to closed shop programming.
>
> Open shop programming should be controlled.
>
> Provision should be made for some special FORTRAN programming on an open shop basis.
>
> Controlled open shop programming for engineering.
>
> Business-closed programming. Technical-open shop programming.

[9] Lawson, op. cit., p. 32.

[10] Ibid.

CHAPTER III

PERSONNEL

A decade or two ago, when the EDP field was in its infancy, technology was the basic problem. Which manufacturer produced the best equipment? Today, the relative importance of the equipment to the data processing manager has and is being steadily reduced by the challenge of an even more difficult problem: the selection, training, evaluation and retention of qualified data processing personnel.

Why the emergence of this problem? Computer manufacturer competition has reached the point where a completely adequate computer and associated equipment for almost any application is available from a number of manufacturers. Couple the above fact with the tremendous expansion of the computer user industry and the reason for the problem and the shift of relative importance is evident. Nor is this user expansion by any means complete.

An attempt to estimate personnel requirements through 1970 was made in an August, 1964, Computers and Automation article by classifying computer installations by size and approximating personnel requirements for each size.[1]

[1] Dick Brandon, "The Computer Personnel Revolution," Computers and Automation, August, 1964, p. 22.

While the assumptions made to obtain the estimates are subject to debate, the point is still made that if current expansion continues through 1970, there is going to continue to be a serious shortage of properly trained computer personnel.

Although the exact impact on personnel requirements of a number of technological changes is a matter of subjective judgement, it is a reasonable assumption that these changes will cause some reduction in the total number of personnel required. Some of these changes are:

1. The use of more advanced languages and compiler systems to reduce or eliminate the routine tedious tasks of programming.

While this change will not eliminate logical analysis, some testing, etc., it will increase the efficacy of many phases of programming such as coding, testing, and much routine.

This will undoubtedly reduce programmer requirements in some measure.

2. More extensive use of more complete libraries will also contribute to a reduction in systems analysis effort.

3. Monitor or operating system control usage by more installations will again reduce operating personnel requirements.[2]

[2] Ibid. pp. 24-25

It is to be emphasized that while the above changes will reduce personnel requirements by some factor, a shortage can still be expected for the immediate future.

As is true of any activity, in the final analysis, people are responsible for the success or failure of a computer facility. It logically follows that one of the keys to EDP success is competent personnel. The shortage of experienced competent personnel and the lack of sufficient appropriate information concerning them has made computer personnel management a difficult task. The information in this chapter presents itself to the illumination and hopefully the easing of this task.

I. POSITION DESCRIPTIONS

Before discussing the subject of personnel selection, some observations concerning position descriptions are pertinent. The position for which selection is desired must, of course, be defined and obviously the selection problem is made much easier if positions are clearly and specifically described. The selection of a key punch operator offers few difficulties relative to proper position definition, but the selection of a systems analyst presents a considerably more complex problem in this regard. What are the boundaries of the systems analyst position relative to the programmer in particular and others at their particular interfaces?

The definition of positions is influenced by several

factors. In a small installation each person will necessarily have a wider range of responsibilities than would be the case in a larger one. The manager may be forced by small installation size to perform systems analysis, programmer or console tasks and disregard the obvious dangers of loss of perspective, etc., inherent in such action.

Personnel availability also influences position definition. An abundant labor supply allows the larger installation to narrowly define positions and consequently pay lower salaries. Conversely, a scarce labor supply forces broader position definition and higher salaries. This last condition may be illustrated by an example. A good employee is offered a higher salary by a competitor and the existing position description does not support a pay raise to retain the employee. By redefining the position to extend responsibilities and to reduce the supervision required over the position, the new position description can probably support the necessary raise.[3] The above example is quite illustrative, particularly when considering federal civil service.

Decision on the restrictiveness of position definition must give due consideration to the accompanying environment. In general, the more restrictive the definition, the greater

[3] Marvin Wofsky, "Selection, Training, and Evaluation of Personnel," Data Processing, VII (New Orleans: Data Processing Management Association, 1964), pp. 224-225.

the communication problem. Thus, the peripheral influences of each situation must be carefully evaluated and then each individual job defined clearly and specifically.

II. SELECTION

Defining the position, however, is not complete until performance standards have been established. As the subject of standards will be presented in detail in a later chapter, it will not be pursued here except to note that recruiting standards are derived from job standards.

What procedure(s) should be used in selecting data processing personnel? Consideration of this question raises the problem of criteria. Selection criteria might be divided into three categories: education, experience and personal characteristics.

Education

A 1962 System Development Corporation study indicated the requirement of a college degree for trainees in about half the data processing organizations with the emphasis for the degree being expressed strongest in the scientific application fields and a much lesser emphasis in this regard in government, utilities, and financial institutions. Graduate degrees were seldom required. More than 90% of the organizations considered high school completion very important.[4] A

[4] Ibid., p. 225

study conducted by Computer Personnel Consultants Inc. of Chicago, Illinois in 1964, and reported in Business Automation,[5] was based on 270 computer installations throughout the United States and Canada. It indicated only a slight reduction in educational requirements. This reduction consisted of a change from college degree requirements to some college education. The average minimum personnel qualification requirements for the major positions and the frequency with which they were reported are presented in Appendix IV. It should be noted, however, that there is no rule of thumb for determining requirements. The particular circumstances at each installation must be evaluated as to complexity of applications, method of job accomplishment, etc., before a determination is made.

Examination of Appendix IV reveals several interesting points:

1. Some college education is desirable for almost all positions except in the computer operator section.

2. It is desired, if not required, that almost all manager positions be filled by college graduates.

3. Quite naturally the degree of emphasis on functional experience is related to the respective functional speciality.[6]

[5] Jay Mettler, "Profile: Computer Personnel Characteristics-1964" Part 2, Business Automation, April, 1964, p.26.

[6] Ibid., pp. 28-29

Recent experiments showing the high degree of adaptability of high school students to data processing fields and current industry hiring trends indicate, as noted above, that the requirement of a college degree for business data processing is decreasing. This trend is probably also influenced by the shortage of personnel as previously discussed. In general, business-accounting backgrounds are preferred for business data processing and scientific-engineering backgrounds preferred for scientific application. Mathematic backgrounds appear suitable for any application. These last comments of preferences apply primarily to systems analysts and programmers.

<u>Experience</u>

While evident to a degree in industry, there is in government, a tendency to substitute experience for educational background. Both government and industry show a preference for hiring-from-within. It follows that the caliber of those initially hired into the organization must be maintained at a high level or else successive hirings-from-within will meet with declining success.

Some organizations have adopted the quite reasonable personnel policy known as the "policy of competitive staffing."[7] This policy is as follows: When all other factors

[7] Ibid., p. 33.

are reasonably equal, preference is given to promotion or transfer from within the organization. Advancement is not automatic. If no internal candidate meets the desirable as well as the minimum requirements, external recruiting sources are utilized. The best qualified candidate is selected for the position. This policy provides reasonable assurance of obtaining the best qualified persons for vacancies while giving preference to internal candidates.

Personal Characteristics

What personal characteristics are desired and once that is determined, how do we identify and evaluate them?

The selection problem is usually concerned with either the selection of candidates for training based upon aptitude for ultimate satisfactory performance or with selecting experienced personnel based upon accomplishment.

Various industries such as aircraft, banking and department stores, to name a few, have used a number of selection methods in attempting to solve this problem. Examples are: aptitude tests, achievement tests, interviews, personality tests, reference checks, review of school grades, etc. The reliability of these tests has not been sufficiently high and improvement is necessary.

The positions presenting the most difficult problem of selection appear to be those concerning programming and systems analysis. Some of the desirable personal characteristics

of candidates for these positions are: analytical, arithmetic and abstract reasoning ability, broad perspective and, a seeming contradiction, attention to detail. Some methods to identify and evaluate these characteristics (relative to trainees) were mentioned above and will be discussed briefly as follows:

1. Aptitude tests such as the IBM Programmer Aptitude Test (PAT) are directed toward measuring analytical reasoning ability.

2. Personality tests are directed toward evaluating temperament among other factors.

3. Review of school grades while self-explanatory deserves comment. Experiments in this area suggest that school grades measure ability, not application, and are not a guarantee of success.

The other methods mentioned are relatively self-explanatory and will not be separately treated.

The results of several research studies, one by the Rand Corporation and one by the Systems Development Corporation, indicate that no consistent pattern has emerged relative to the value of a specific test nor for the tests in general. No known test or battery of tests consistently predict the level of job performance.

One partial explanation of these results could be the one characteristic approach of several of the tests. Another

explanation might be that a wide variety of kinds and levels of jobs were included under the same title and that the jobs investigated were not sufficiently and clearly defined.[8]

One factor alone has appeared to assert itself and this factor was observed primarily in the area of trainee programmers. Above the minimum intelligence level...

> It begins to appear that the dominant personal characteristic for successful programming is the desire--the determination to succeed...[9].

An Aid to Selection

The selection problem is frequently complicated by the difficulty of insufficient easily obtainable information on candidates. One possibility for easing this difficulty is to develop a comprehensive list of the various skills, techniques and tools utilized by fully trained personnel for each specific position. This list should enumerate the various skills and levels of proficiency within each skill and be under two headings--theory and practice. Present employees and all job applicants would fill out the list.

Potential employees could complete the list prior to interview and thus enable more efficient use of interview time. Later use of the list in conjunction with interview

[8] "Selecting EDP Personnel," EDP Analyzer, Vista, California: Canning Publications, Inc., July, 1964, p. 6.

[9] Wofsky, op. cit., p. 227

evaluation would contribute to better selection. Appendix V illustrates a possible list.[10]

Recommendations Concerning Selection

Reasonable trainee selection effectiveness can be obtained by using interviews, reference checks and (for programmers and systems analysts) aptitude tests for analytical ability.

Reasonable experienced personnel selection effectiveness can be obtained by using interviews, reference checks and appropriate proficiency or achievement tests (e.g., develop a flow chart from a narrative of a problem in a specified time period.)

III. EDUCATION AND TRAINING

Many authorities in the data processing field agree that the basic management computer problem is education. Ned Chapin says that the knowledge of how to secure data processing objectives depends primarily on the training, experience and supervision of personnel. The effectiveness of this knowledge depends upon its amount and relevance, which in completing the circle depend upon training and education.[11]

[10] Leonard Lee, "Stuff=Instant Facts," Data Processing for Management, July 1964, pp. 31-33.

[11] Ned Chapin, "Data Processing Problems for the Sixties," Data Processing, July 1960, p. 14, cited by Wofsky, op. cit., p. 227.

A United States Air Force publication indicates that the success of data processing depends upon the effective training of supervisory personnel.[12]

In the remarks which follow, the terms training and education will have reasonably precise meanings. The word education will refer to the long range instruction intended to broaden the student's knowledge. The word training will refer to the short-range instruction intended to provide or increase knowledge in a particular area.

Education

There are rewards and penalties to educating employees. The major advantage is obtained from the employee's broadened scope which enables him to operate at a higher echelon than previously. This added knowledge may enable the employee to improve existing or develop new systems. An obvious disadvantage is that as the employee's value increases, competitors may offer the employee a higher salary and benefits. The original company must develop vigorous retention incentives. Another disadvantage is that a replacement must be obtained and paid while the employee is away at school in addition to the educational expenses.

It would appear from the number of agencies sending

[12] Department of the Air Force, Management of Data Processing Equipment, Washington, D.C.: March 1964, p. 81, cited by Wofsky, op. cit., p. 228.

employees and military personnel to college on degree programs that the rewards exceed the penalties.

Colleges and Universities. An increasing number of colleges and universities are offering degree programs in computer allied fields. American University in Washington, D.C., and certain others, offer fairly comprehensive degree programs in data processing. The rapid growth and change in the data processing field make carefully evaluation of course content and depth a prerequisite to selection for employee education. A reasonably complete listing of colleges and universities offering data processing courses is available in Data Processing Yearbook 1963-1964, pp. 219-282.

Part-time programs. Many agencies pay employees' tuition to attend university sponsored, after-working-hour, courses. Some agencies have contracted with universities or consultants to conduct courses during working hours. These courses are, of course, especially tailored to company needs.

Junior colleges and high school courses. Many junior colleges and high schools are offering programs in data processing. These agencies can be helpful in two ways. First, they can increase current employee value to the company and secondly, they may provide a source for satisfying new personnel needs.[13]

[13] Wofsky, op. cit., pp. 228-232.

Training

Specific training of employees in the tasks for which hired is imperative. General education in the broad concepts of the installation also will contribute to more effective and competent output.

Training should probably begin with some classroom instruction to initiate and/or reaffirm grasp of tasks and concepts. Then the application of classroom instruction to on-the-job tasks should follow.

The objective of training is, of course, to insure specialized knowledge in a particular area. Some companies have adopted this policy instead of education because they desire immediate results which can be had quicker and cheaper by training rather than by education. Both education and training are necessary in proper balance. As long as the limitations of both are fully recognized, programs incorporating either or both may attain desired objectives.

IV. WORK RESPONSIBILITIES RELATIVE TO EDUCATION OR TRAINING

While the data processing manager usually has no authority relative to personnel outside the data processing department, it is still to his advantage to know what factors contribute to securing the support and guidance of top executives and middle management. For this reason, comments concerning these two areas will be incorporated in this paper.

Executives

Managerial officials must understand something of the computer's potential relative to "management by exception" and "Total Systems" before being able to secure efficient, if not optimum, advantage from it. Executives learn by their daily contacts with data processing, but formal attention is needed to assure that the proper depth and broadness of knowledge is obtained.

If teaching ability and knowledge is available in the organization, executive courses tailored to the organization's needs may be developed. Relevant examples from work experience are especially instructive. If the internal capability is unavailable, other sources for instruction are:

1. computer manufacturer courses,
2. contracts with consultants or universities,
3. attendance at seminars and institutes sponsored by organizations such as the American Management Association,
4. use of computerized management games to introduce the concepts and potentials of simulation.

Sources 3 and 4 must be used in conjunction with sources 1 and 2 if a balanced and comprehensive understanding is to be achieved.

Middle Management

Courses much like the executive ones can be used, but more depth in systems analysis, design and programming is

preferable. This background enables them to more fully appreciate the effort and difficulties caused by failure to carry out prescribed procedures or by changes.

Personnel Providing Input or Using Output of Computer

Incorrect input, obviously, causes unsatisfactory output. In this regard, the people who provide input must be trained in correct procedures and techniques of input preparation and additionally should be introduced to the broad aspects of the system in general and the specific details of the part in which they are involved in particular. They should be shown examples of common errors, the consequences of incorrect input and how to avoid making the errors.

People using the output should be made aware of how to recommend improvements such as the elimination of extraneous output.

Manager of EDP

The manager, within limits, has the responsibility for the success or failure of the installation. It is not necessarily essential that he be an expert in every or any phase of the operation. He must, however, have a firm basis of broad and general knowledge of all areas. In this regard he should take orientation courses covering all phases of the installation. In particular, he should take specific courses covering installation equipment. These courses are usually available from the manufacturer.

Although management of an EDP installation is a full time job, the manager must be able to appreciate programming difficulties and to estimate programming time. This facility can be gained through learning to write and machine-test a relatively simple program, through advice from the senior programmer and through a careful review of programming performance standards.

The manager should take the same course(s), especially those on concepts and procedures, as his systems analysts to facilitate communications on matters of systems analysis and design.

If part of the installation is EAM, a knowledge of their capabilities and speeds are necessary. The manufacturer and/ or on-the-job training provides this information.

One of the more beneficial policies for the education and training of the EDP manager is that secured by attendance at meetings of professional organizations and visits to other installations. Subscription to professional journals, etc., will also contribute.[14]

Programmers

The problem of proper training of programmers has been attacked by many agencies. When the results have been sifted, the most effective and commonly accepted approach appears to

[14] Ibid., pp. 233-238.

be that initially he goes to school. Here he obtains an understanding of the principles of data processing, equipment operation, block diagramming, flow charting and card and form design. He then takes a course or courses in the specialized programming techniques for the specific computer used by his organization. This school training period varies from one to three months. When he knows the computer commands and how they should be used, he is placed in the programming department for on-the-job training in local procedures and is given progressively more difficult problems.

Experience indicates that programmers working in an integrated systems environment must know the entire system in some detail and parts of it in complete detail to be able to satisfactorily discharge their duties. This points up the additional requirement for systems training in these instances.

Relative to the last paragraph, it is worthy of note that organization for work accomplishment influences the degree of emphasis needed on systems training. One method of work is to assign one person to carry a project through from beginning to end. A second method is to assign two or more persons to work as a "team" in taking a project from beginning to end. This method is generally the most profitable one. A third method is to break the project down into functional specialties and assign one person to do defining

and diagramming and another to do some other phase such as coding.[15] Depending upon the method used, the various types and degrees of training will and probably should vary.

All training must take consideration of the heterogeneity of the trainee's background of experience, education, training and learning speed if results are to be fully satisfactory. Careful selection policies and/or programmed-learning text books can help to alleviate this problem.

The usual elapsed time between the beginning of training and a positive contribution to programming effort, is from six months to a year.

Systems Analysts

Training programs for systems analysts present a substantial problem compared to that for programmers. A major difficulty appears to be the lack of knowledge as to what really needs to be taught. Various agencies have attempted and are continuing to try to solve this problem of systems analysis and design training.

The subjects most often cited as valuable are systems design, integrated data processing, analysis of file maintenance, analysis of source documents, flow charting, computer orientation, work on organization charts and computer programming.

[15] "Planning for an IBM Data Processing System," IBM F20-6088-1, White Plains, New York: IBM Technical Publications Department, p. 12.

Experience and logic support the position that a computer programming course is a definite requirement. With such a background, the analyst more fully understands computer operations and programming problems.

Console Operators

Console operator training has essentially been on-the-job training. Occasionally a short manufacturer's course in console operation has been included.

Before the question of qualifications is presented, the duties of the position should be defined. First he must "load" the computer correctly. This involves obtaining the appropriate current tapes, file protected, and mounting them. If card input is required, he must obtain the correct input cards and often must make up control cards for them.

Once the setup is complete, the job must be started. This usually requires the pushing of a few buttons.

Occasionally trouble is encountered in trying to run a job. When this happens, the experienced, competent operator may be able to save the run or at least continue operations without assistance. Additionally, he can generally furnish valuable information as to what and where the problem is. Problems are usually one of three general types: improper tape or card input, a program problem or an equipment failure. The operator's swift recognition of the problem type and accurate description of conditions, enables speedy correction.

On completion of the job, the operator must "unload" the output, taking care to prevent destroying or misplacing it.

With the above as background and the fact that experience has shown that it is more economical to batch programs for testing and running successively, the need for a well trained and competent operator is apparent.

What are the qualifications of a good console operator? He must know some programming, have a general understanding of the file flow for the various runs and, of course, know how to operate the computer. He must possess patience and have training in the "why" as well as the "how" so that he can exercise care and good judgement.

If the console operator is not well trained, much of the effort expended in systems analysis and/or programming may be wasted. The number of reruns or bad tapes are indicators to help recognize a good or bad operator.[16]

V. SALARIES AND SOURCES

Salaries

Salaries for data processing positions in government installations are established by law. Information concerning positions and salaries can be obtained from Industrial Relations Offices.

[16] H. Krueger, "The Console Operator," Data Processing For Management, January 1964, pp. 50-51.

As a point of interest and to provide an example from which to gain some appreciation of size and salary, two federal activities will be briefly mentioned. The Naval Supply Center, Oakland, California and the Naval Supply Center, Norfolk, Virginia have automatic data processing installations consisting of both EDP and EAM facilities. Each activity (Norfolk and Oakland) employs approximately 265 personnel. These personnel are distributed roughly half and half between EDP and EAM. The senior civilian (Deputy Director of the Data Processing Division/Department) at each installation is a GS-14 with a salary between $14,000 and $18,000 a year.

A research study of 1,200 companies in 308 cities in 48 states and Canada conducted by Philip H. Weber and Associates, Inc. of Chicago, Illinois[17] on data processing employee compensation presented average salaries for the key supervisory positions. Appendix VI is a tabular reproduction of that data. Averages are of questionable value and therefore will not be pursued further. Several salary trends such as those for senior programmer and senior procedure analyst are significant and deserve comment.

Because of the expanding scope and complexity of data processing functions, an increasing demand is being felt in

[17] Richard Kornblum, "Annual Survey of Data Processing Salaries," Business Automation, June 1964, pp. 26-35.

the requirements for more complex computer programs to handle intricate applications and to only a slightly lesser extent in procedures. Salaries in these areas have a significant upward trend which is expected to continue into the immediate future.

Detailed information concerning computer personnel staffing practices, position descriptions, salaries, etc., across the country is available in Computer Personnel Characteristics-1964.[18]

Sources

Sources for the recruitment of data processing personnel are the same as those used by industry for other recruiting. In general they are:

1. internally,
2. personnel firms,
3. organization advertising,
4. college recruiting-primarily for trainees,
5. business, technical and high school-primarily for trainees.

It has been suggested that a potential source of computer personnel is high school students of potential college

[18] "Computer Personnel Characteristics-1964": A Report Prepared by Computer Personnel Consultants, Inc. on Computer Personnel Salaries, Staffing Practices and Position Descriptions, (Chicago: Computer Personnel Consultants, Inc.), pp. 1-20.

caliber who are unable to go to college because of personal or financial reasons. These people could be started at an appropriate level on the condition they take two college courses each semester at company expense.

VI. EVALUATION

Successful evaluation of data processing personnel requires the establishment of job standards for each position. The techniques of job standard establishment are covered in the chapter on standards and will not be pursued further here. Without standards, evaluation of personnel performances is largely subjective and open to bias.

It is therefore absolutely essential that valid standards be established, continuously reviewed and impartially used.

CHAPTER IV

DOCUMENTATION AND CONTROLS

Highly essential to responsive and efficient operation of the data processing function is a well defined system of procedures and effective management controls. Because of the technical nature of data processing and the mobility of data processing personnel, documentation plays a major role in facilitating communications, preventing the development of conflicting procedures, standardizing operations during personnel turnover, and simplifying on-the-job training. An effective system of controls serves to insure that maximum production is achieved, that accurate cost records and personnel and machine utilization records are kept, and that data is accepted and processed, completely, accurately and on schedule, without loss or alteration.

This chapter examines the documentation requirements for run manuals, console run books, and procedures manuals. Information on documentation was taken largely from International Business Machines, Planning for an IBM Data Processing System, IBM form number F20-6088-1. Budgetary and financial controls, operating controls, internal controls and the basic concept of the audit trail are also examined.

I. DOCUMENTATION

The Run Manual

The Run Manual is a program manual which provides a written record of everything pertinent to the run and consists of a programming and an operating section. The programming section is described in further detail in Chapter V. The Run Manual should contain sufficient information so that an experienced programmer who is not familiar with the run would be able, within a reasonable period of time, to become sufficiently conversant with it to determine causes of trouble and make the necessary changes. It should also be sufficiently detailed that if system requirements change, modifications could be made as efficiently and expeditiously as possible.

The Run Manual should contain the following items:

1. The program name and number.

2. A description of the purpose of the run.

3. A complete set of flow charts. These should include detailed flow charts cross-referenced to the coding (showing for each symbol the starting line of the coding which performs that operation.) To establish the context of the run, a top level flow chart which indicates how the run fits into the system may be included.

4. The date written or date of last modification and the name of the programmer.

5. A narrative description of the run.

6. A printed listing of the program.

7. A summary of computer operating instructions, including labels and descriptions of tapes and their disposition, error or special procedures, rerun instructions, average runtime, and switch settings.

8. Suggestions for future changes and special warnings about making changes.

9. Alternate program listings by instruction location, operand, operation code, accumulators, etc. as required.

10. Delineation of required peripheral equipment and its program address.

11. Running time required with estimated or actual adjustments for volume variations.

12. A listing of all input required and its source. Estimated volumes should also be indicated.

13. A listing of output materials, form numbers, quantities, etc.

14. Disposition instructions for input and output materials.

15. A sample of each report produced by the program.

16. Detailed layouts of tape input records, tape output records, and punched card input and output.

17. Control panel wiring diagrams and narrative wiring descriptions.

18. Storage allocation used including input, output and working areas, subroutines, main program, constants, variables

and auxiliary storage requirements by type.

19. Uses and contents of index registers, accumulators, etc.

20. A description of provisions for program interruption and restart.

Console Run Book

To assist the console operator, information from the operating section of the Run Manual needed to operate each program, is separately documented for use at the console. Although every attempt should be made to have this as complete as possible, provision should also be made for ready access to the Run Manual. A separate Console Run Book may be maintained for each run, although a series of runs for a particular application may be placed in one run book. The Console Run Book should contain:

1. Identification of tape units which are to contain the input and those which are to contain the output.

2. Action required concerning external tape labels.

3. Console switch settings.

4. A listing of program switches with their designation, location, settings and purposes.

5. A list of all program halts and prescribed corrective action.

6. A description of restart procedures or reference to standard restart routine.

7. A description of exceptions to other standard routines.

8. A description of input data, library tapes, program tapes, etc. required to run the program and their source.

9. Disposition and retention instruction for input, program, and output materials.

10. Computer test procedures.

11. Action to be taken when an unanticipated stop occurs.

12. Sample running time.

13. Minimum configuration necessary to run the program.

14. A detailed list of sequenced set-up instructions.

General Procedures Manual

The general procedures manual contains a written record of policies, procedures and techniques for standardized use throughout the data processing organization. This manual is used to provide instructions for standard operation of the data processing function. Items to be included in the General Procedures Manual are:

1. An organization chart of the data processing operation.

2. Responsibilities and duties of personnel.

3. Machine scheduling policies and procedures.

4. Standard format for the Run Manual with specific instructions for timely correction or modification.

5. Standard flow charting and block diagram techniques to be used.

6. Programming languages available and general guidance of when to use each language.

7. Macro instructions and/or subroutines to be used.

8. Utility programs to be used.

9. Record retention policies.

10. Program desk-checking procedures.

11. Program testing procedures.

12. Program restart procedures.

13. Standard programming techniques.

14. Allocation of storage locations, index registers, alteration switches, etc.

15. Tape labeling procedures.

16. Tape handling rules

17. Tape error correction procedures.

18. Halt addresses to be used.

19. Program and tape library rules.

20. Exhibits of input documents with full instructions for preparation and transmittal.

21. Exhibits of output forms and reports with an explanation of their contents, discussion of frequency, etc.

22. Timing schedules for data submission and receipt of reports.

23. Procedures for handling special circumstances.

II. CONTROLS

One of the keys to administering an efficient data processing operation lies in recognizing it as a production

function.[1] As such, efficient operation depends to a large extent on the installation of effective controls. Three basic types of control are financial and budgetary controls, operating controls, and internal controls. These control types are described in further detail in the following paragraphs.

Budgetary and Financial Controls

Effective budgetary and financial controls require that a budget be established, that a reporting system which compares actual to estimated performance be employed, that variances be analyzed and explained and that action be taken to correct any off-standard condition. The system to be used is based on the application of cost accounting to the computing area. The reporting system should provide intelligence on costs incurred in terms of jobs, projects, applications, etc. Breakdowns of personnel and machine usage should be sufficiently detailed to provide a basis for determining the costs of particular jobs, providing cost data for special studies, and justifying the ADP budget including requirements for new equipment, additional personnel, multi-shift operation, overtime, etc.

Two basic concepts of budgeting and reporting are in

[1] B. W. Ziessow, "Managing the Data Processing Operation," Data Processing for Management, March 1964, p. 12.

general use: the burden center and the profit center.[2] In the burden center method, an expense budget is prepared detailing all expenses, presented to management and accepted, modified, or rejected based upon the overall benefits provided. Monthly, actual expenses are reported against authorizations and variances are explained. The burden center method is most commonly used for small to medium data processing activities servicing a single plant or distinct operating entity.

The profit center method is normally used when the computer facility is operated as a service bureau. Under this concept, rates are established for all services provided. Customers are billed monthly on the basis of actual or estimated processing times and budgeted revenues are determined from estimated monthly billings. Expenses are detailed for budget purposes as under the burden center concept. Monthly reports, comparing budget with actual revenues and expenses are provided for review and analysis.

With respect to the assignment of costs for processing data, two methods are widely used: average cost and marginal cost.[3] In the data processing operation, some costs can be

[2] Ibid

[3] Robert H. Gregory and Richard L. Van Horn, Automatic Data Processing Systems: Principles and Procedures, (Belmont: Wadsworth Publishing Company, Inc. 1963) p. 581.

identified with a particular project or job. These costs correspond to production costs. Other costs such as equipment depreciation, supervision, supplies, etc. cannot be easily identified with a particular project. These correspond to production indirect costs. The average cost method is used to distribute costs so that total costs are completely distributed. The average cost scheme is particularly attractive in those activities which have a high proportion of fixed costs with little variation due to changes in the volume of data handled. Marginal costs represent the amount of cost change as volume changes. Under a marginal costing system, only the additional costs incurred for a particular job are charged to that job.

Both systems have differing reactions to volume changes. For a system with large fixed costs, the average cost is high when volume is low, and low when volume is high. High average cost tends to discourage equipment use while low average cost tends to encourage it. Thus average costing may lead to either too light or too heavy a workload for maximum efficiency. Marginal cost is more sensitive to system load. When workload is light, marginal cost is small and encourages use. When equipment is fully loaded, marginal cost is high and discourages use. Since marginal cost is the full increase in costs for equipment, personnel and supplies it is particularly high for the first application and for

those applications which require more equipment or multi-shift operation.

Operating Controls.

Operating controls consist essentially of scheduling controls, procedural controls, tape controls, and operator controls. Each will be discussed in turn.

Scheduling controls. Scheduling is probably the most difficult yet most important task in operating a data processing installation. All work must be done on time and in the proper sequence. Scheduling involves not only the central processing unit but also all auxiliary equipment as well. Workload must be planned well ahead of execution time. Flexibility is best obtained by scheduling at less than full capacity. This entails a delicate balance between a schedule tight enough to guard against loss of valuable machine time but loose enough to provide for setup time, delays, temporary loss of coordination with auxiliary operations, emergency requirements, etc. Times for testing new programs must also be considered, as production processing tends to push aside new program debugging since it is not immediately productive. Provision must also be made for maintenance and equipment testing in determining the overall schedule.

The operating schedule may be established to show both scheduled and actual operations. This will permit periodic evaluation in order to render improved service, to adjust for

new applications, to insure compatibility with actual needs, and to determine areas of difficulty. In addition, machine utilization and employee activity records may be used to record actual machine time and clerical time spent on each application. These records serve to control efficiency and provide the basis for estimating processing time for new applications.

Procedural controls. Procedural controls serve to avoid misunderstanding, simplify on-the-job training, alleviate disruption due to turnover or reassignment of personnel, and provide the basis for critical evaluation of current operations. These controls consist primarily of the General Procedures Manual and the Run Manual along with other specific written procedures such as card punching and verifying instructions, peripheral equipment operating instructions, etc.

Tape controls. Rigid tape controls are vital for effective operation of the data processing installation. Such controls must provide for proper tape labeling and effective library routines to prevent erasing master records, use of incorrect tapes, and loss of data through mishandling.

Proper tape labeling involves both external and internal labels. The external permanent label is affixed upon receipt of the tape from the manufacturer and shows reel number, date received and length of tape. When the reel becomes active, a semi-permanent external label is also used. This label

should contain information such as file number or name, reel number, output tape unit address, the number of runs it is used on, and scratch date. To segregate applications, colored labels may be used. Internal labels are records written on the tape. These records usually contain file number, reel of file, date written, scratch date and file description. The checking or identification of the internal tape label is normally done by a combination of programming and visual checking through the computer printer or console typewriter. The purpose of this check is to verify that the file number is correct for the program being run, that the sequence is proper if the input file contains several reels, that the file is on the proper tape unit, and that the scratch date has been reached before the tape is written on.

Effective library procedures entail the maintenance of accurate and up-to-date records, proper handling to prevent damage or loss of records, and efficient cycling to minimize investment in tape by re-use as soon as possible after the scratch date.

The choice of the record system depends, to a great extent, on the size and activity of the tape library. As a minimum, the record system should provide the physical location of any given file, a written custody receipt for items removed from the library, information on tapes whose scratch dates have expired and which are thus available for further

use, and a catalog or index of files and reels in the library.

Equally effective procedures must be established to maintain control of the program library containing such items as program master tapes, program card decks, utility programs, subroutines, control panels, printer carriage control tapes, etc.

Detailed instructions on tape labeling and tape and program library procedures should be included in the General Procedures Manual.

Operator controls. One of the necessary factors for the success and operating efficiency of the data processing activity is competency of console operation. The primary means of attaining competency in console operation is through well trained operators and the provision of detailed operating instructions as contained in the Console Run Book. To insure that the system is functioning properly, an extensive computer test may be developed to be run by the console operator at the beginning of each shift. A continuous machine utilization record or operating log should be kept at the console to record programs run, starting time, completion time, tape drives used, auxiliary equipment used, setup time, rerun time, idle time, etc. Additionally, the console operator should be provided a form on which to record the status of the console when an unanticipated stop occurs. This form is of value to programming and maintenance personnel to help

detect the cause of the stop.

Internal Controls

Separation of duties among personnel responsible for originating and processing data and maintaining custody over property so that no one person has complete control over all phases of a business transaction meets the internal check and control standards of sound management. Such a division can be accomplished by separating duties into initiation of data (input), processing and accumulation of data (machine operation), and summary recording and review of data (output).

Input controls are involved with insuring that input data are reliable and properly authorized. The possibility of error in the first recording of data can be reduced through simplifying and standardizing forms, developing specific instructions, using precoded forms as much as possible, prenumbering documents, requiring review and approval of recorded data, etc. All data received for processing in the computer facility should be recorded in a suitable log or register. After the data is recorded, it must be protected from loss, distortion, and introduction of erroneous or unauthorized data. One technique to avoid errors is the use of control totals. Through this technique, batch totals of dollar amounts, quantity amounts, transaction counts, documents, etc., provide controls to insure processing of all data and a basis for subsequent checking of

processing accuracy. A technique which can be used when a high level of accuracy is required and when data is highly critical or important is for the data processing installation to provide a listing of the input for the source department to verify on an item-by-item basis. Other input control techniques are editing routines such as limit check, field check, sign check, validity checks and self checking numbers. Data which is received in written form for conversion to card or tape input is particularly subject to error. Although the use of batch controls and editing routines can detect many errors in data conversion, if data to be keypunched is very important, it may be necessary to key-verify the punching to detect errors.

Accurate processing and accumulation of data is dependent upon the accuracy of the programming, manufacturer's checks built into the system, and the checks developed by the user. Full advantage should be taken of built-in checks to preclude duplication in developing programmed controls. These controls are used to detect data loss or non processing, check arithmetic functions, avoid data misposting, and control programs against inaccuracies or alteration due to equipment malfunction or operator error. Controls against program error or equipment malfunction include recorded label checking, record counts, file totals, address checks, double

arithmetic, programmed halts and overflow procedures.[4] Programmed controls against operator error include setup checks, file restrictions, intervention records, scuttle procedures and suspense accounts.[5]

Output controls are used to determine that the processed data are correct and do not include unauthorized alterations. Output control techniques include computer-generated totals, control by exception, systematic sampling, and statistical analysis. Computer-generated totals at the point of input and upon completion of each major processing routine permit determination that all data were processed or are contained in exception reports. Exceptions resulting from programmed controls or from failure to meet editing procedures provide a basis for investigation, correction and reprocessing. Exceptions are normally controlled through a log which identifies the exception, its cause, and its disposition. Systematic sampling is used to check representative transactions, critical or highly important data, and the quality and form of the output printing. In addition, sampling should be done on a statistical basis to determine the accuracy of master file records which are not subject to the usual review

[4] International Business Machines. Management Control of Electronic Data Processing. IBM form number F 20-0006-0. White Plains: International Business Machines, 1965, pp. 13-14.

[5] Ibid

but which are subject to deterioration over a long period. Statistical analysis is used as an aid to checking the relative accuracy of the processed data by comparison with data processed previously or with projected estimates.

III. THE AUDIT TRAIL

A fourth type of control feature which must be considered is the audit trail. The purpose of the audit trail is to provide:[6]

1. Transaction documentation detailed enough to permit identification with its original source document.

2. An accounting control system which proves that all transactions have been processed and that accounting records are in balance.

3. Sufficient documentation so that any transaction can be re-created and its processing continued, should the transaction be misplaced or destroyed somewhere in the procedure.

To allow maximum system utilization, the audit trail should be designed to satisfy the needs of both management and the auditor and to be produced incident to other operations of the system. Care must be exercised to avoid excessive or voluminous amounts of printouts.

Two methods can be used to provide an audit trail, the

[6] International Business Machines. Document and Accounting Controls. IBM form number C 20-8060. White Plains: International Business Machines, 1961, p. 15.

direct and the indirect.[7] With the direct method, the system produces a punched card containing details of all transactions processed. Cards are then listed in a transaction register and sorted or filed by account or activity to provide a current analysis file. This method places a heavy burden on output equipment and reduces efficiency. In addition, it requires the maintenance of card files as well as other stored data.

The indirect method consists of programmed controls to provide details of the items that comprise a control balance at a given date, to produce detail listings of transactions which can also be used for operating analysis, budget comparison, etc., and to provide sufficient reference or identification in the master record to permit special printouts of information as required.

[7] Ziessow, op. cit. p. 14.

CHAPTER V

STANDARDS

The spectacular growth of the electronic data processing field has not been accompanied by a corresponding growth rate in uniform work methods, procedures and disciplines. It has however been accompanied by a scarcity of competent managerial and technical personnel. The personnel scarcity (treated in Chapter III,) the high growth rate of the data processing function and its technical nature, have been prime factors in the failure to develop adequate standards.

In any undertaking, management's ability to control an operation has its basis in a feedback cycle. In general, the cycle consists of the taking of some action, observing the result, evaluating the result and taking subsequent adjustive action to achieve particular objectives. Thus the cycle goes round and round. An ineffectual or non-existent feedback cycle effectively isolates management from the operation and obstructs the exercise of appropriate control. The result is management inability to accurately judge (among other things) project completion dates or costs.

The feedback cycle must be established if effective management control is to be achieved. To this end, two types of standards are necessary. The first, methods standards, establishes guidelines of uniform practices to create uniform

output. The value of methods standards lays in their improvement in communications. This last deserves further comment. Methods standards require analysts, designers, programmers, operators, etc. to produce diagrams, flow charts, programs and operating procedures in a uniform manner, understandable to others and with a basic amount of documentation as to problem approach, solution and procedure. When this type of standard is developed, the effects of personnel turnover are reduced because personnel trained in the standard methodology can quickly take over the vacated position tasks; more accurate performance standards can be established because all positions of a type perform the same basic activities; and uniform methods permit division of work without a major communications problem. The second, performance standards, specifies the amount of work expected to be accomplished during a given time period. This yardstick enables management to:

1. develop more accurate schedules,
2. develop realistic costs and budgets,
3. develop hiring and training standards,
4. equitably evaluate personnel for promotion and for compensation in accordance with their contribution,
5. assign tasks in accordance with ability.

The methods standards and the procedures governing the establishment of performance standards should be compiled

and placed in the standards section of the General Procedures Manual. The standards section should have four major divisions. They are:

1. systems analysis standards
2. programming standards
3. equipment performance standards
4. personnel performance standards

The remainder of this chapter will treat each of the above divisions in turn.[1]

I. SYSTEMS ANALYSIS STANDARDS

The machine-assisted solution of a problem is, in general, achieved by performing four basic tasks. They are:

1. problem analysis--the problem is defined and a determination made as to what specifically is required for a solution.

2. system analysis--the machine solution is defined in broad outline. This definition provides the connecting link between the problem analyst and the programmer.

3. programming--the defined machine solution is translated into computer language by the programmer.

4. operation--the machine executes the input instructions and produces the solution.

[1] Dick H. Brandon, "The Case For Data Processing Standards," Computers and Automation, November 1963, pp. 28-31.

Depending upon installation size, one or more of the above tasks may be accomplished by one person. But, most commonly, the tasks are accomplished on a strictly functional basis. Whatever the method used, examination of the systems analyst functions reveals evidence that here creativity probably contributes more to the development of effective systems than any other single factor. For this very reason these efforts must be effectively channeled and documented if maximum value is to be obtained and retained. Thus standardization is necessary if the creative effort expended on systems analysis is to be preserved and made available as a basis for evaluating and predicting performance.

What are the usual systems analyst functions? Normally, the following functions are required:

1. design of input, output and record layouts,

2. design of the overall information flow through the system,

3. development of the specifications for each program in the system including timing analysis, program description, statement of controls and audit trails to be maintained and a statement of the program functions.

The above functions are then combined to form the basic output of system analysis, the Job Specification Manual. This manual is a complete description of the problem to be solved. Obviously, the Job Specification Manual is of little use if

the originator is the only one who can understand it. If every element in the manual is of a standard type, the communications problem is solved and additionally a basis is present for conducting performance evaluations.

What are the primary areas where standards are needed to assure this objective? They are:

1. terminology--standardized terms and definitions should be used,

2. layouts--specified levels of detail desired are necessary, standard forms and format should be used, contents of tape records should be specified,

3. numbering system--a standardized numbering system should be designed for control systems, programs, forms, tapes, and card files which is understandable to all,

4. flow-charting--detailed standards of symbology, format, chart types (macro/micro) must be established,

5. document analysis--standard methodology and procedures must be used to ensure ease of communication and measurement and enable work scheduling.

Thus the standardization of methods, symbology, terms, and number codes reduces the communications problem and enables the systems analysis section to produce detailed job specifications which contain everything needed for the programmer to produce computer programs for solving problems.[2]

[2] Dick H. Brandon, "Systems Analysis Standards," Computers and Automation, December 1963, pp. 18-21.

II. PROGRAMMING STANDARDS

It should be recognized that the Job Specification Manual is the sole input to the programmer. Therefore, the initial task must be its critical review for adequacy. This means that the system description and flow chart design must be sufficiently specific and complete. If the specification is acceptable, the programmer assumes complete responsibility for the job.

The programmer takes the Job Specification Manual prepared by the systems analyst and, in effect, translates the broad outlines of the problem solution into programming and equipment operating instructions. These instructions then become the contents of a Run Manual. The formulation of those instructions pertaining to programming requires the following functions to be undertaken:

1. logical analysis--development of block diagrams which present a graphic representation of the machine steps,

2. coding--translation of representation into a symbolic language,

3. desk checking--checking of steps to insure all appropriate conditions have been anticipated,

4. test data preparation--development of input data to use to check if the program, as written, properly recognizes all conditions,

5. assembly and test--actual machine processing of

program and test data to verify correctness,

6. documentation--preparation of a complete detailed description of the program and its operation,

7. installation--assisting operating personnel in using the program and correcting any errors.

All of the above functions must be performed in a standard manner if the objectives of uniform product, efficient scheduling, performance evaluation and personnel interchangeability are to be obtained.

Block Diagramming

A programmer's first step after acceptance of the specification is to identify the major logic steps or blocks of programming (macro-blocks) and to prepare a diagram which shows the interrelationships of these macro-blocks. When the task of macro-block diagramming has been completed for each program in the specification, the programmer and systems analyst review them to insure the programmer understands the specification requirements and also to reappraise the optimality of logic and system design. Each macro-block is then diagrammed separately and in detail to show the calculations and relationships necessary for problem solution. These diagrams are called micro-blocks.

It becomes fairly obvious that the drawing of block diagrams can become quite individualistic unless detailed standards are established. These standards should cover the

kinds of diagrams desired, their format, the method of diagramming, the level of detail desired and the coding scheme to be used. Each of these points will be discussed in brief in the following paragraphs.

Kinds. Two kinds of diagrams, macro and micro as presented above, should be prepared. The micro-diagrams should be identified to a specific macro-block. Additionally, both types should be machine independent.

Format. A format should be prescribed. It should include the kind of paper, its size, margin requirements, method of page numbering, and minimum block diagram identification requirements such as program name and number, programmer's name, date and block number and description.

Method. Standard symbols and abbreviations must be used to prevent a communications problem.

Complexity. Levels of detail required must be established. This is a very difficult standard to establish because the size and nature of programs differ, but some rules can be established. An example of such a rule follows: programs will be divided into major logical steps of not more than a designated number of blocks.

Coding Scheme. Linkages between macro-block, micro-diagrams and coding are necessary to permit tracing of steps to solution. Therefore, some standard coding scheme is necessary. One possibility is to assign a capital letter to

each macro-block. The corresponding micro-block would then be assigned its macro-block letter plus a number. Corresponding coding sheets could then be assigned its capital letter-number plus a small letter. Whatever the scheme, a standard method greatly simplifies review.

Coding Method

A standard coding method is necessary to conserve memory space and to prevent two programmers from using the same label for different purposes. If the programs are to be run together then the labels may be doubly defined. Avoidance of this problem and the establishment of a standard consists of analyzing programs to determine major classifications and then adopting a group of labels to correspond to the classifications. An illustration might be the label CC 11. The first C indicates a constant, the second C indicates a counter and the 11 indicates counter number 11. While this example is relatively elementary and restrictive, the method of attack is identical for the more complex and detailed coding frequently required in comprehensive programs.

Program Organization

The first page of coding should contain comment cards detailing information on factors such as console set-up, input-output device usage and input and output tapes to be mounted so that an initial set of operating instructions are available during testing. Housekeeping functions, loading

sequence, subroutines, memory usage, etc., should immediately follow so that the complete program organization is established.

Programming Rules

Programming restrictions imposed by machine and assembler design should be stated along with a list of common causes of errors.[3]

Testing

Certain testing procedures are necessary to detect the majority of errors. Some errors will be detected only under unanticipated operating conditions. These test procedures should be applied to the program in chronological order after coding.

Desk checking. The programmer first reviews the program for completeness of general logic and correction of clerical errors, missing labels, etc. An effective technique to accomplish this review is to trace some sample data through the program. A second programmer should then perform the same review as a double check.

Program preparation. The program is ready for input preparation after desk checking is complete. The program is key punched and possibly run through card machine operations of sorts, merges or collations to eliminate clerical

[3] Dick H. Brandon, "Standards For Computer Programming Part 1," Computers and Automation, April 1964, pp. 20-27.

errors and validate operation codes, etc.

<u>Assembly</u>. The program is assembled; invalid labels, operation codes and other errors are identified and corrected; and the program reassembled.

<u>Program testing</u>. The program is loaded into the computer and various fabricated input data is used to test the program's ability to process possible inputs. In this process each logic block is individually tested for proper functioning. The blocks are then tested together to insure proper program functioning. Again failures or errors are identified and corrected. It is to be emphasized that each time changes are made to the program, appropriate changes should also be made to symbolic decks, coding sheets, block diagrams, etc., as applicable.

Upon completion of testing, certain information should be retained. This includes the test plan, the test results summary, last memory condition upon end of program loading, input data listing and last output listing of that data. This information is essential to insure that any future change can be checked with this data to insure no other sections of the program have been affected.

<u>Documentation</u>

The information developed by the preceding functions must be properly presented before effective use may be made of it. The programming section of the Run Manual mentioned

earlier is where this task is accomplished.

This section contains such information as:

1. memory layouts to explain program memory usage,

2. tape layouts to specify each tape used,

3. arrays used and how they may be updated,

4. detailed description of the program and each of its logic blocks,

5. macro-block diagrams as previously described,

6. micro-block diagrams as previously described,

7. lists of helpful information about counters, constants, and buffer areas used and any other significant factors,

8. listing and explanation of special program features, cautions, etc.

9. dated latest assembly listing of program,

10. memory dump to assist in error correction,

11. listing of all final test data used.[4]

III. EQUIPMENT PERFORMANCE STANDARDS

The establishment of equipment performance standards is necessary to:

1. establish reasonably accurate equipment scheduling,

2. control equipment costs of acquisition, operation and growth through analysis of performance versus needs,

[4] Dick H. Brandon, "Standards for Computer Programming Part II," Computers and Automation, May 1964, pp. 22-43.

3. facilitate budgeting,

4. facilitate personnel performance evaluation.

However, before developing standards, the environment under which the equipment operates and is measured must be defined. In general, this environment is classified by its organizational relationships and the time allowed for solution once the solution is requested and the input data is available. An illustration of the above would be where the computer is part of some larger system (a component of it) and accomplishes a particular job by a fixed completion time.[5]

Once the equipment environment(s) is determined, measurement standards can be established. An outstanding aid in establishing or evaluating equipment standards is Standard EDP Reports developed by the Auerbach Corporation of Philadelphia, Pennsylvania. This reference service's primary function is to assist prospective computer users in selecting equipment configurations for installation. After the following description of the information available from this source, its importance for the establishment or evaluation of equipment performance standards will be evident.

Each report is divided into the following sections:

1. Introduction: a summary of the system's characteristics and features, with particular emphasis upon its strengths and weaknesses relative to competitive systems.

[5] Robert L. Patrick, "Measuring Performance," Datamation, July 1964, pp. 24-25.

2. Data Structure: how the system represents basic data units.

3. Internal Storage: the size, spread and characteristics of each available type of data storage unit (core, thin-film, disk, drum, etc.).

4. Central Processor: a user oriented specification of the capabilities of the processor including operations performed, special features, and times required to perform standard tasks such as addition for five-digit numbers.

5. Input-Output Units: specifications of each of the peripheral units available with the system, including basic speeds, error checks, compatibility of the external storage medium with other systems, etc.

6. System Configuration: diagrams illustrating the number of typical equipment configurations, including inter-connection restrictions and component rentals.

7. Simultaneous Operations: a detailed description of the system's capabilities to reduce total job-times by performing more than one operation at a time.

8. Physical Characteristics: a summary of the characteristics pertinent to physical installation problems.

9. Price Data: rental, purchase and maintenance costs for each system component.[6]

Each report also provides a measure of the system's overall performance by precisely defining typical bench-mark tasks such as mathematical calculations. These tasks are used to measure each computer system at three levels: central processor, individual devices, and particular system configurations. This is accomplished by obtaining the

[6] Norman Statland, Manager, Business Information Systems, Auerbach Corp., "Methods of Evaluating Computer Systems Performance," Computers and Automation, February 1964, pp. 19-20.

manufacturer's fundamental performance specifications for each unit, developing times required for each elementary task on each unit and then combining the times for the units in a configuration.[7]

Whatever the source of bench-mark times used, each program or "average" program of a type must be subdivided into its component bench-mark tasks, the times aggregated and equipment standards obtained.

A second and considerably more subjective method is that presented by Dick Brandon.[8] In this approach, estimates of standards are made based upon operating parameters which are in turn developed through exercise of judgement and experience. A schedule is then established based upon these estimated standards. Detailed, accurate records are kept on actual performance. Causes for deviations between performance and schedule are determined. If a consistent pattern over sufficient experiences is established, the applicable standard is modified accordingly.

Before discussing in more detail what parameters are used and how they are used in developing the estimates, it is essential to recognize that certain basic elements are

[7] Ibid.

[8] Dick H. Brandon, Management Standards For Data Processing, New York: D. Van Nostrand Company, Inc., 1963, Chapter VIII.

necessary to the establishment and use of performance standards.

1. Method standards must be established and enforced,

2. Accurate and detailed records of performance are necessary.

Three parameters generally used to estimate time standards are:

1. Program size--an estimate or actual count of the number of pages of coding (usually divided by ten) necessary for a program. This count is used to anticipate the compile time.

2. Program complexity--an estimate of the degree of program complexity as determined by an experienced programmer. A simple code can be used such as: A-simple, B-moderately difficult, etc. Two factors must be considered when establishing a complexity code. First, the same person should make the complexity estimate on all programs. Second, program complexity and program size must be estimated separately because there is no direct relation between the two.

3. Input-Output complexity--the number of input-output units necessary for the program is obtained by analysis of the program flow chart or the operating manual.

Each program therefore has these three parameters which can be used to estimate the standard desired.

An example of developing a standard for compiling time

by program is given to illustrate how the parameters are used. A program is analyzed and assigned its three parameters. In this example the numbers of compiles as well as the time for each compile are important as the number provides an indication of the accuracy of coding and number of clerical errors while the time per compile is an indicator of efficiency in machine operation.

The number of compiles is a direct function of complexity and size while the compile time is a direct function of size. Suppose the program had been rated moderately difficult and of size 2. Then experience and judgement might suggest three compiles of six minutes each would be necessary. Actual time and compiles would be recorded and compared with the estimates.[9]

Comment

It should be noted that equipment performance and personnel performance are not always clearly distinguishable. Equipment is essentially self-controlled and a variation from a standard does not necessarily indicate lower equipment efficiency. The variations probably indicate weakness in personnel performance such as programming or operator effectiveness. Thus care must be taken to define what is meant. If the character transfer speeds are being considered,

[9] Ibid, pp. 215-216.

that is definitely equipment performance. If program run time is being considered, equipment and personnel performance distinctions are difficult to make. Commonly, the definition used is broad and is applied to situations such as program run time and compile time.

IV. PERSONNEL PERFORMANCE STANDARDS

The efficient operation of any installation staffed completely or in part by people must have performance measurements and standards by which to evaluate that performance. This is required for personnel evaluations relative to training, pay, promotion and work assignment; for developing hiring and separation policies; for work scheduling; for budgeting control; for facility capacity determinations.

Personnel performance standards are presented for systems analysis, programming, and operating personnel.

Systems Analysis

The development of performance standards for the system analyst is based largely on subjective estimates or parameters. A number of these parameters are discussed as follows:

1. Complexity--quite obviously, the more complex a problem, the more time likely to be needed to solve it. A scale of complexity such as A-simple, B-moderate, etc. can be set up and problem complexity estimated by the most experienced analyst.

2. Number of documents--the number of different docu-

ments the analyst must analyze or design will also influence time required.

3. Number of steps--the number of steps performed or to be performed in some problem solution again affects time required.

It is readily apparent that different problems alter the particular tasks and times required. In general however, the tasks common to system analysis in the broad sense may be categorized. Then as each problem is encountered, tasks may be eliminated if inappropriate. These tasks are:

1. assemble available information,
2. interview personnel on current system,
3. flow chart the present system,
4. analyze present system documents and files,
5. flow chart new systems,
6. design or redesign documents and files
7. describe both systems
8. develop layouts,
9. develop timing,
10. prepare job specification manual.

Time required to complete each of the above tasks considering the parameters of complexity, etc., are estimated. The task of assembly of data can be used to illustrate the technique. The most experienced analyst estimates that one hour is required for finding, analyzing, extracting and

assembling the data from each document, plus the addition of a time factor to account for complexity such as one-half a man day for each document of a moderately complex problem. When the times for the applicable tasks are aggregated, an expected performance time is obtained. A schedule is then established on the basis of these estimated times. Records are kept on actual performance of each task. Variances between actual and estimated performance are analyzed and appropriate remedial steps taken relative to standards or to personnel.

The initial standard set by this approach could rightly be expected to be of little value. However, with the same person estimating the parameters and actual performance experience to validate the times associated with the parameters, a good workable set of standards can be obtained.[10]

Programming Quantity Standards

The development of performance standards for programming personnel is approached in a manner similar to that used for systems analysts. The steps are:

1. listing of basic tasks performed,

2. grouping of tasks into sets,

3. develop relationship between tasks and time to perform them,

[10] Ibid, pp. 292-294

4. establish a schedule based on these time estimates,

5. record actual performance,

6. analyze variance between actual and estimated performance,

7. take appropriate remedial action.

The grouping of basic tasks are as follows:

Group 1.	Macro-logic:	job specification analysis review of functions layout analysis program flow chart macro-block diagram
Group 2.	Micro-logic:	micro-block diagramming logic review
Group 3.	Coding:	translation item layout coding standard subroutines
Group 4.	Desk checking;	desk checking listing validation test data preparation
Group 5.	Testing:	assembly or compilation program testing production testing systems testing conversion and installation assistance
Group 6.	Documentation:	documentation proofreading block diagram updating program turnover [11]

Parameters of complexity, size, etc., are again applied to each task. Time estimates for the particular value of

[11] Ibid, pp. 251-252.

the parameters are aggregated to obtain total time. Actual performance is recorded and compared with the estimates. Analysis of variances is made and appropriate action taken.

It should be noted that the tasks and groupings listed above are those concerning the development of an entirely new program. However, the combination of programming tasks differs under different circumstances. Under varying situations, only the tasks actually involved are considered. The identical procedure is then followed to obtain the standard.

Programming Quality Standards

The methods described so far have been applicable to establishing quantity standards. Nothing has been presented concerning the establishment of quality standards. It is necessary that minimum quality standards be established for a given quantity of output per time period. Although the determination of quality is largely a subjective matter, there are some objective elements. One method which has attempted to at least partially quantify quality standards has been presented by R. V. Jordan.[12] This approach, called Programmer Proficiency Profile, consists of three major divisions: present proficiency, projected proficiency and programmer excellence. Each division contains a number of performance factors, each of which have been assigned points.

[12] R. V. Jordan, "Programming Talent Can Be Measured," Datamation, July 1962, pp. 49-51.

The relation of the points of one factor to those of the other factors (regardless of divisional lines) indicates the relative importance of that factor.

A programmer's work is evaluated in terms of each factor and points are assigned. Comparison of the programmer's individual and aggregate points with the maximum points possible and with his contemporaries provides a measure of individual and competitive work quality.

The divisions, their respective factors and method of computation are as follows:

Present proficiency.

1. Effective rate of computer utilization (ERCU)--25 points.

$$\frac{\text{total development time on the computer} - \text{total development time lost for program errors}}{\text{total development time on the computer}} \times 100 = \text{ERCU}$$

Example: Rate 80%, then 80% x 25 points = 20 factor points.

2. Quality audit of documentation of programming effort--20 points. This factor provides incentive for producing documentation concurrent with programming.

Ratings Possible Per Item

Zero	Poor	Fair	Good	Excellent	Superior
0	1	2	3	4	5

Items Considered

a. program narrative

b. general flow chart

c. input and output format

d. memory layout

e. detailed language bubble chart

f. program header

g. data defining chart

h. file specification chart

i. coding sheet

j. test data and/or conversion program

The programming effort is audited considering each of these ten items as appropriate and a rating assigned for each item. The maximum evaluation per program would be 10 items x superior rating of 5 for each = 50 points.

Then: $\dfrac{\text{total score attained}}{50 \times \text{number of programs scored}} \times 100 = \%$ of maximum score

This percentage times 20 equals factor points.

3. Adequacy of operating instructions--15 points. The purpose of measuring this factor is that poor or inadequate operating instructions may necessitate reruns.

<u>Rating of Items</u>

<u>Poor</u>	<u>Good</u>	<u>Outstanding</u>
0	1	2

<u>Items Considered</u>

a. starting address

b. corrections

c. input

d. typeouts

e. restarts

f. legibility

g. entries complete

The maximum evaluation per program is 7 items x outstanding rating of 2 for each = 14 points.

Then: $\dfrac{\text{total score attained}}{14 \text{ x number of programs scored}}$ x 100 = % of maximum score

This percentage times 15 equals factor points. If in actual operation, failure is attributable to operating instructions, one point is subtracted from the factor points.

Projected proficiency.

1. Progress Analysis of Programming Plans--15 points. This factor is considered to insure that procrastination does not consume time in the preparatory stage. If quantity standards are not valid enough, each programmer will establish dates for completing the following program milestones:

a. systems design

b. general flow charting

c. detail flow charting

d. coding

e. assembly

f. debugging

g. production

Evaluation consists of determining if milestone dates were

met. Failure to meet any one milestone removes that program from scoring.

Then:
$$\frac{\text{number of programs which met milestone dates}}{\text{number of programs in planning state}} \times 100 = \text{Planning Effectiveness Rate}$$

This percentage times 15 points equals factor points.

2. Number of assemblies versus established mean for assembly runs--10 points. Any program for which number of assemblies is larger than the mean is termed sub-standard.

Then:
$$\frac{\text{Number of programs assembled} - \text{Sub-standard assembled programs}}{\text{Number of programs assembled}} \times 100 = \text{Assembly Performance Rate}$$

This percentage times 10 equals the factor points.

3. Number of debug runs versus established mean for debug run--10 points. Any program for which the number of debugs is larger than the mean is termed sub-standard.

Then:
$$\frac{\text{number of programs debugged} - \text{sub-standard debugged programs}}{\text{number of programs debugged}} \times 100 = \text{debugging rate}$$

This percentage times 10 equals factor points.

4. Time spent debugging versus mean time for debugging a program--5 points. Each program debugging time which exceeds the mean would result in a penalty of 1 factor point. For example, if only one program was run and its debugging

time exceeded the mean, then the factor points would be 5 - 1 = 4 points.

It is recognized that more complex programs may require more debugging time than the mean. Allowance for this fact is made in the Programmer Excellence division.

Programmer excellence. This division is intended to permit supervisors to identify subordinates worthy of merit mention. The supervisory programmer alone determines these subjective scores. Being totally subjective, these factors run the usual risk of bias.

1. Optimization Programs--5 points

All indicators of optimization such as short run time and efficient use of monitor levels contribute to the judgement.

2. Complexity of Programs--5 points

The experience of the lead programmer coupled with a consideration of the various routines, tables and instructions necessary are the elements used to determine complexity and subsequent score.

3. Programming Workload--5 points

Size and type of workload carried by one programmer relative to the others are the elements the lead programmer must recognize in awarding factor points.

Since arraying personnel in these quantitative terms may not adequately describe or allow for special conditions,

a narrative explanation section may be added when appropriate to explain some misleading or special fact.

Although the preceding method is largely subjective, it does present one of the vew few formal approaches to the problem of establishing a measure of the quality of programmer performance.

V. OPERATING PERSONNEL STANDARDS

The development of operating personnel standards is intimately associated with machine operation. As pointed out in the section on equipment standards, the distinction between operating personnel performance and equipment performance is vague except in the tasks of set-up and take-down. For these two tasks, the technique of time and motion study can be applied. In other tasks, the analysis of variance between actual and standard equipment performance may identify operating personnel performance deficiencies.

VI. GENERAL COMMENTS ON STANDARDS

The value of accurate standards is in the information provided by their comparison with actual performance. This implies the collection of actual performance data. The collection system should be simple and reliable. This is sometimes simpler said than done. Various types of clock timing devices make the collection of machine performance data relatively easy. The unbiased, reliable recording of data by programmers, analysts and operators is usually more

difficult. Therefore, rather rigid instructions, printed forms and enforcement are necessary to secure accurate and relevant data.

Effective management requires the establishment of standards, a comparison of the standard with actual performance and the intelligent use of the resulting information.

CHAPTER VI

SUMMARY AND CONCLUSIONS

With the increasing use of data processing equipment and procedures, formerly decentralized responsibilities for processing large amounts of data are being concentrated in the data processing activity. How well this activity discharges its responsibility can well spell success or failure to the entire enterprise. To a great extent, proper utilization of the data processing tool depends on the quality of data processing management.

Surprisingly little definitive guidance exists on the management aspects despite the proliferation of data processing literature. This paper is an attempt to present what are considered to be the major elements involved in managing the data processing operation.

Five key elements--organization, personnel, documentation, controls, and standards--are considered significant for successful management of this function.

The data processing activity must be located in the overall organization so as to contribute most effectively to enterprise objectives, to obtain support and cooperation, and to permit accurate appraisal and evaluation of its performance. Of the three types of organizational location examined, the data processing function operated as a separate

and distinct entity is considered to provide the best alternative for development of an integrated, automated management system and for realizing the full potential of computer application. The data processing function itself must be organized internally to insure that all necessary functions are performed and that responsibilities are assigned for their performance. The best internal organization is dependent upon many factors such as size; type of activity, e.g. commercial or scientific; variety and depth of skills required; and technical competence of personnel. Thus, no one internal organization pattern can be considered generally best under all conditions.

An especially difficult personnel problem is faced by the data processing manager. This problem is caused by the tremendous rate of expansion of computer users and the unique degree of competence and sophistication required of data processing personnel. Thus, progressive personnel policies for selection, education, training, incentives, and retention are vitally important to aid in alleviating this problem.

Two of the most important factors contributing to responsive and efficient operation of the data processing function are a well defined and documented system of procedures and effective management controls. Documentation plays a major role in facilitating communications, preventing

development of conflicting procedures, standardizing operations, and simplifying training. An effective system of controls--predicated upon the establishment of standards against which methodology, equipment and personnel performance can be compared--serves to insure maximum production, the maintenance of accurate cost and utilization records, and complete and timely processing of valid data without loss or alteration.

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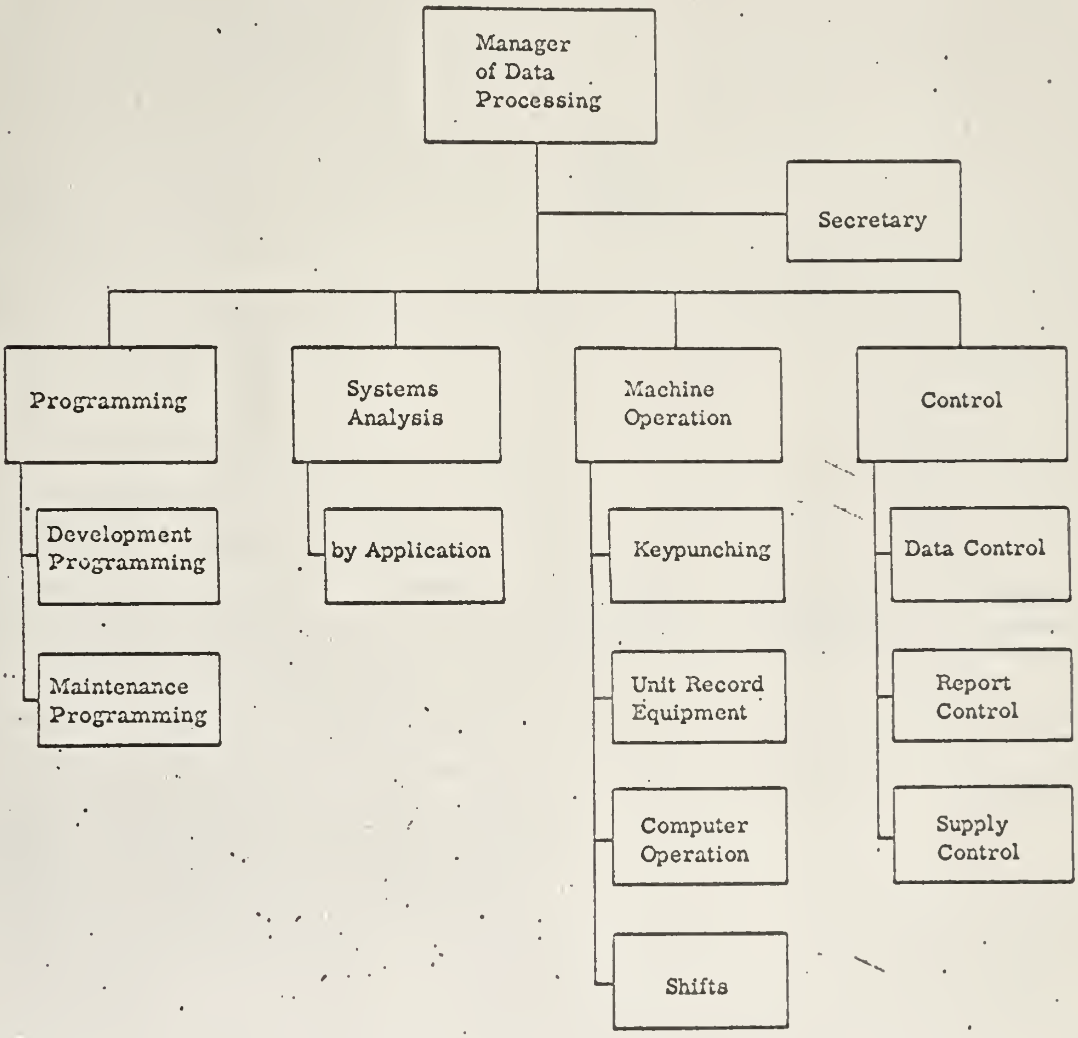
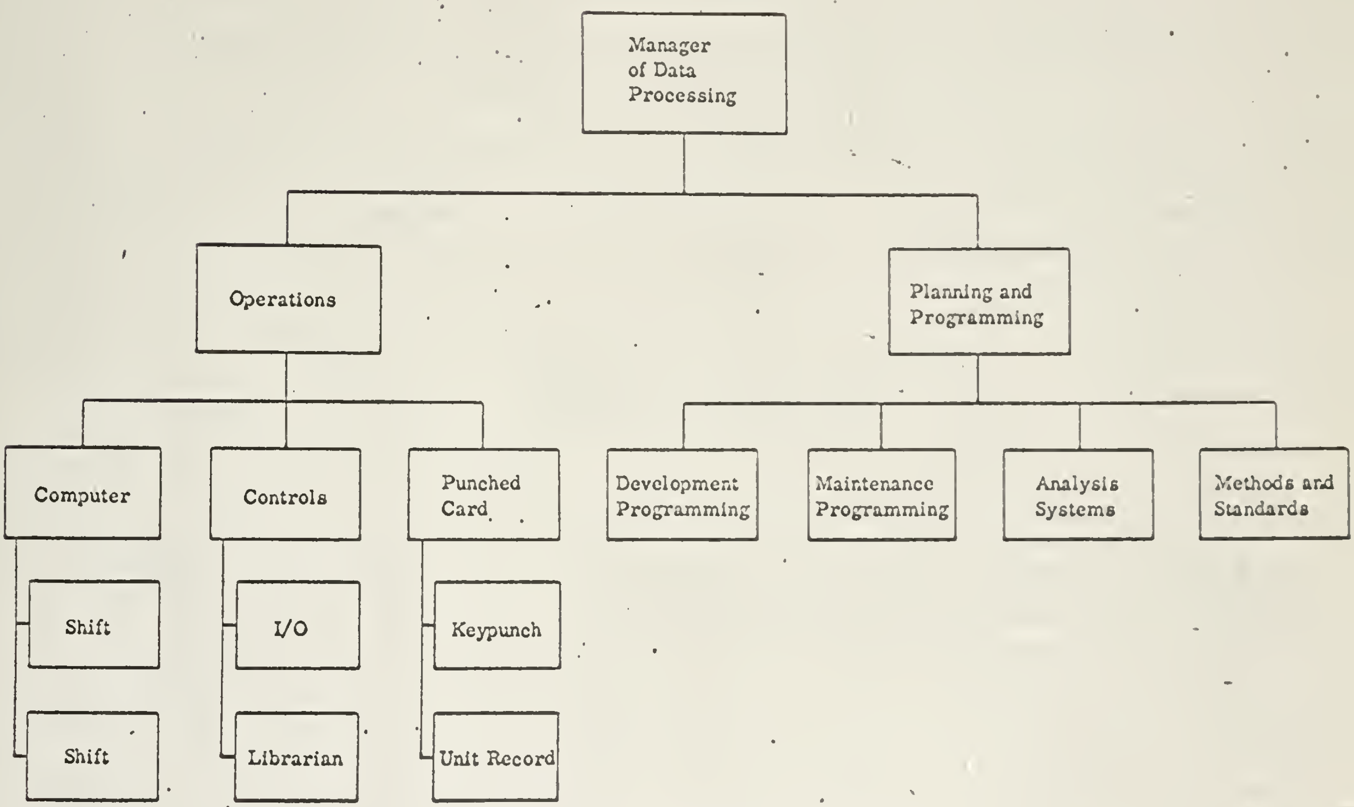
APPENDIX I

FUNCTIONAL ORGANIZATION



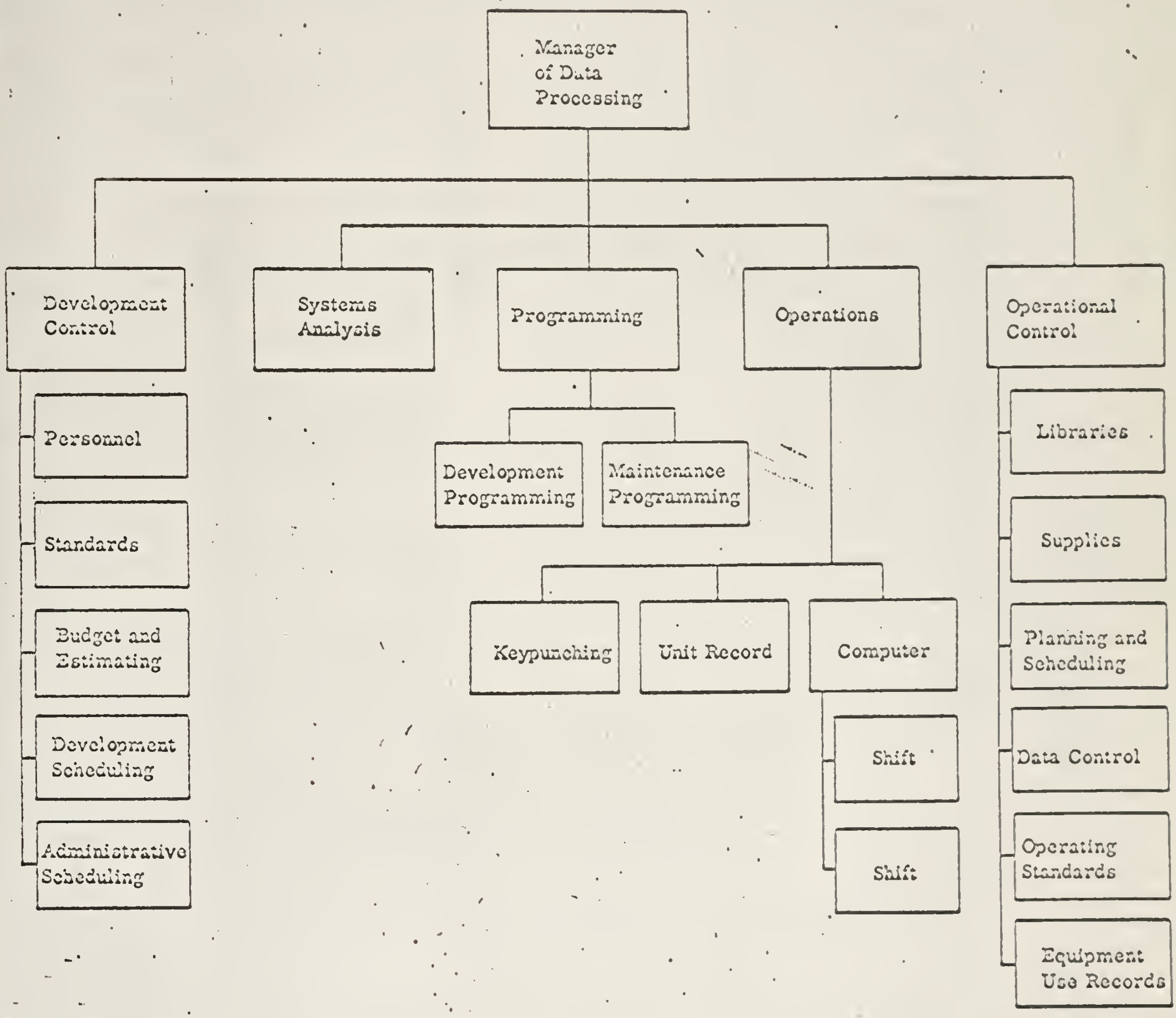
APPENDIX II

GROUPED FUNCTIONAL ORGANIZATION



APPENDIX III

STAFF/LINE ORGANIZATION



MINIMUM COMPUTER PERSONNEL QUALIFICATION REQUIREMENTS

COMPUTER PERSONNEL CLASSIFICATION	EDUCATION	TOTAL EDP EXPERIENCE (Months)	MONTHS OF FUNCTIONAL EXPERIENCE					TYPE OF INDUSTRIAL EDP EXPERIENCE (6 Months or More)			TYPE OF COMPUTER EXPERIENCE (6 Months or More)			
			Dept. Control	Systems Analysis	Programming	Computer Operations	EAM Operations	Specific Industry	Same General Industry	Any Industry	Specific Computer	RAM Computer	Tape Computer	Card Computer
DEPARTMENT CONTROL														
Manager of Data Processing	College Graduate	48	12*	24****	12****	12*	12*		**	**			**	*
Asst. Mgr. of Data Processing	Some College	42	12*	18****	12****	12*	12*		**	**			**	*
Technical Assistant to the Mgr.	Some College	30	12*	12***	12***	6*	12*		**	**			**	*
Coordinator of Computer Opr.	Some College	18		6**	12**	6*	12*		*	***			*	**
Work Process Scheduler	Some College	12		6*	6*	6*	12*		*	***			*	**
SYSTEMS ANALYSIS SECTION														
Manager of Systems Analysis	College Graduate	42		30****	12***	6*	6*		**	**			**	*
Lead Systems Analyst	Some College	36		24****	12***	6*	6*		**	**			**	*
Senior Systems Analyst	Some College	18		18***	6**				**	**			**	*
Systems Analyst — A	Some College	12		12***	6**				*	***			*	**
Systems Analyst — B	Some College	6		6**	6*				*	***			*	**
Systems Analyst — C	Some College	No Experience Required												
PROGRAMMING SECTION														
Manager of Programming	College Graduate	36		6*	30****	6*	6*		**	**			**	*
Lead Programmer	Some College	24			24****	6*	6*		**	**			**	*
Senior Programmer	Some College	18			18***	6*	6*		**	**			**	*
Programmer — A	Some College	12			12***	6*	6*		*	***			*	**
Programmer — B	Some College	6			6**				*	***			*	**
Programmer — C	Some College	No Experience Required												
COMPUTER OPRNS. SECTION														
Mgr. of Computer Operations	Some College	36				30****	18*		**	**			**	*
Lead Computer Operator	High School	24				24****	12*		**	**			**	*
Senior Computer Operator	High School	18				18***	12*		**	**			**	*
Computer Operator — A	High School	12				12***	12*		*	***			*	**
Computer Operator — B	High School	6				6**	6*		*	***			*	**
Computer Operator — C	High School	No Experience Required												

Note: The numbers indicate the average months of experience that is required. The asterisks indicate the percentage of companies requiring the experience using the following coding:

* 20% - 40%
** 40% - 60%
*** 60% - 80%
**** 80% and over

SAMPLE SKILL AND PROFICIENCY LISTING

a

MANAGEMENT ANALYST SKILLS & TECHNIQUES

INSTRUCTIONS: Indicate your degree of familiarity with each item listed by checking appropriate boxes in theory and practice columns. Also indicate number of years work experience in last column. Check "NONE" category if you are not sufficiently acquainted with subject to discuss or apply the skills, techniques or tools involved.

	THEORY Reading and discussions				PRACTICE Actual work experience				
	NONE	LIMITED	MODERATE	EXTENSIVE	NONE	LIMITED	MODERATE	EXTENSIVE	NO. OF YRS.
1. Conduct comprehensive management surveys (Procedures/organizational) — ALONE									
2. " " " — AS TEAM MEMBER									
3. " " " — AS TEAM LEADER									
4. Conduct special studies									
5. Conduct manpower surveys									
6. Prepare written survey reports — PARTS OF REPORTS									
7. " " " " — COMPLETE REPORTS									
8. Prepare staff studies or other problem solving type reports									
9. Prepare procedures manuals/SOP's									
10. Prepare formal directives and regulations									
11. Administer directives management program									
12. Develop organizational policies									
13. Conduct formal briefings/oral presentations									
14. Instructor — Work simplification course									
15. Instructor — Other management subjects									
16. Conference discussion leader									
17. Perform organizational analysis and planning									
18. Perform space analysis and layout studies									
19. Space and facilities planning, allocation and control									
20. Operate records management program									
21. Reports analysis and control program									
22. Forms analysis and design									
23. Operate forms control program									
24. Correspondence analysis and systems									

b

MANAGEMENT ANALYST SKILLS & TECHNIQUES

INSTRUCTIONS: Indicate your degree of familiarity with each item listed by checking appropriate boxes in theory and practice columns. Also indicate number of years work experience in last column. Check "NONE" category if you are not sufficiently acquainted with subject to discuss or apply the skills, techniques or tools involved.

	THEORY Reading and discussions				PRACTICE Actual work experience				
	NONE	LIMITED	MODERATE	EXTENSIVE	NONE	LIMITED	MODERATE	EXTENSIVE	NO. OF YRS.
25. Procedures flow charting									
26. Process analysis charting									
27. Break-even charting									
28. Line of balance charting									
29. Linear responsibility charting									
30. Gantt charting									
31. Work simplification program techniques									
32. Work measurement and counting									
33. Work sampling									
34. Predetermined time standards									
35. Engineered time standards									
36. Methods time measurement									
37. Time-motion studies									
38. Statistical analyses and presentations									
39. Preparation of visual and graphic aids									
40. Manpower control programs									
41. Manpower staffing standards									
42. Position classification and job analysis									
43. Employee (industrial) relations practices									
44. Operate incentive awards program									
45. Civil Service personnel regulations									
46. Military (Army) personnel regulations									
47. Knowledge of TAGO organization and functions									
48. Knowledge of TAGO policies and directives									

c

MANAGEMENT ANALYST SKILLS & TECHNIQUES

INSTRUCTIONS: Indicate your degree of familiarity with each item listed by checking appropriate boxes in theory and practice columns. Also indicate number of years work experience in last column. Check "NONE" category if you are not sufficiently acquainted with subject to discuss or apply the skills, techniques or tools involved.

	THEORY Reading and discussions				PRACTICE Actual work experience				
	NONE	LIMITED	MODERATE	EXTENSIVE	NONE	LIMITED	MODERATE	EXTENSIVE	NO. OF YRS.
49. EQUIPMENT MANAGEMENT (selection, evaluation, controls, standardization, specifications)									
50. Equipment comparison matrices									
51. Equipment utilization studies									
52. Knowledge of EAM equipment & operations									
53. SDA equipment and operations									
54. ADP (EDP) equipment & operations									
55. Specialized accounting machines									
56. Other office/business machines									
57. Office equipment, supplies, and aids									
58. Reprography equipment and operations									
59. Graphic arts equipment and techniques									
60. Microfilm equipment and operations									
61. Optical scanning devices									
62. Magnetic ink character equipment & systems									
63. Mark sensing									
64. Port-a-punch									
65. Communications equipment and systems									
66. Materials handling equipment and operations									
67. Warehousing operations and practices									
68. Postal equipment and operations									
69. Library equipment and operations									
70. Filing equipment and systems									
71. Transportation equipment and procedures									
72. Packaging equipment and operations									

d

MANAGEMENT ANALYST SKILLS & TECHNIQUES

INSTRUCTIONS: Indicate your degree of familiarity with each item listed by checking appropriate boxes in theory and practice columns. Also indicate number of years work experience in last column. Check "NONE" category if you are not sufficiently acquainted with subject to discuss or apply the skills, techniques or tools involved.

	THEORY Reading and discussions				PRACTICE Actual work experience				
	NONE	LIMITED	MODERATE	EXTENSIVE	NONE	LIMITED	MODERATE	EXTENSIVE	NO. OF YRS.
73. ADP (EDP) operations									
74. Preparation of ADP feasibility studies									
75. Block diagramming									
76. ADP programming									
77. OPERATIONS RESEARCH									
78. Linear programming									
79. Queueing theory									
80. Inventory analysis									
81. Simulation techniques									
82. Game theory									
83. Multiple regression analysis									
84. Exponential smoothing									
85. Simplex									
86. Transportation									
87. Assignment									
88. Allocation									
89. Bayesian analysis									
90. PERT TIME									
91. PERT COST									
92. Quality control									
93. Production control and planning									
94. Budgeting and expense controls									
95. Performance analysis									
96. Internal audits									

ANALYSIS OF KEY SUPERVISORY POSITION SALARIES BY METROPOLITAN AREAS

Metropolitan Areas Surveyed	Manager of Computer Operations			Ass't Manager of Computer Operations			Technical Ass't to the Manager			Supervisor Procedures and Analysis Section		
	Low	Av.	High	Low	Av.	High	Low	Av.	High	Low	Av.	High
Atlanta	166	206	240	140	153	170	*	*	*	140	177	195
Baltimore	164	250	336	*	*	*	135	159	185	153	183	204
Boston	200	273	397	134	185	233	154	199	230	163	202	341
Buffalo	154	233	392	153	231	325	189	246	271	155	205	254
Chicago	138	245	365	158	194	250	148	208	268	130	214	202
Cincinnati	187	239	307	178	214	250	158	188	201	230	250	280
Cleveland	171	231	323	144	184	202	162	195	263	197	250	306
Columbus, Ohio	170	208	277	160	172	180	143	166	181	148	180	211
Dallas	132	204	321	97	147	197	130	159	190	156	199	240
Denver	135	201	248	170	183	196	142	165	188	178	210	279
Detroit	127	231	346	178	196	214	136	143	150	185	228	270
Indianapolis	245	295	392	204	250	316	*	*	*	191	233	275
Kansas City	173	202	232	155	162	167	165	196	226	178	203	219
Los Angeles	138	249	420	115	219	291	151	211	277	145	227	340
Louisville	155	187	204	130	155	179	*	*	*	159	257	355
Milwaukee	155	208	276	152	175	196	*	*	*	162	204	275
Minneapolis-St. Paul	162	252	327	133	179	214	170	219	268	138	214	296
Newark	180	282	380	181	215	245	*	*	*	143	249	308
New Orleans	148	245	294	152	175	196	125	141	163	135	155	175
New York	150	279	529	143	229	347	108	196	326	163	221	432
Philadelphia	178	218	247	*	*	*	*	*	*	169	220	308
Pittsburgh	185	251	403	236	251	269	*	*	*	198	230	280
Portland	130	160	212	148	172	196	*	*	*	161	200	250
St. Louis	229	260	294	185	188	194	*	*	*	152	210	243
San Francisco-Oakland	140	216	342	108	189	270	133	163	186	158	198	233
Seattle	161	200	280	138	179	213	123	132	145	165	223	280
Washington, D.C.	230	269	320	192	227	275	*	*	*	225	242	268
200 Misc. Areas	128	219	381	115	196	346	115	187	289	140	214	305
Nationwide—All Cities	127	233	529	97	192	346	108	182	326	135	214	432

Supervisor Programing Section			Supervisor Computer Operating Section			Machine Accounting Manager			Tabulating Supervisor			Key Punch Supervisor			Tabulating Record Control Supervisor		
Low	Av.	High	Low	Av.	High	Low	Av.	High	Low	Av.	High	Low	Av.	High	Low	Av.	High
140	154	178	125	134	150	111	144	210	75	98	133	86	94	112	86	96	102
135	198	260	137	158	179	136	191	303	89	123	214	89	122	164	181	195	209
143	205	283	107	155	194	122	173	277	100	137	199	77	120	194	83	123	175
135	140	144	160	187	214	120	158	204	*	*	*	103	123	142	92	105	117
156	199	286	115	172	269	186	192	308	103	157	223	71	121	254	70	123	187
158	196	219	109	146	192	103	162	209	109	152	213	83	103	118	*	*	*
138	170	202	123	172	225	138	183	273	100	153	202	79	134	214	*	*	*
125	164	188	141	152	167	170	218	246	102	139	163	76	103	141	100	114	121
127	222	295	96	135	229	120	160	235	98	126	189	82	111	155	104	110	116
150	182	208	122	161	191	109	164	258	103	124	157	70	108	176	89	106	127
146	200	243	141	186	231	121	202	258	105	152	212	94	137	191	123	169	231
128	190	260	135	188	230	130	154	166	115	122	129	70	130	220	*	*	*
173	218	242	110	162	184	125	196	252	100	147	200	90	123	139	*	*	*
148	217	260	125	177	260	176	234	330	95	146	230	95	129	205	98	114	125
*	*	*	152	164	175	171	186	204	138	144	155	96	117	138	118	118	118
144	173	231	138	158	184	103	173	206	127	149	175	81	113	152	*	*	*
136	201	301	101	152	204	120	176	223	82	133	188	73	107	148	120	164	187
143	214	285	110	180	250	153	206	289	110	145	193	91	122	155	125	139	147
125	145	165	100	148	196	147	181	219	71	119	160	78	98	132	143	143	143
137	215	312	108	177	254	113	203	322	93	152	273	76	127	225	71	143	193
157	236	286	127	168	232	112	184	270	92	136	187	64	115	148	95	106	116
174	212	262	127	177	198	157	201	265	118	141	190	122	147	185	77	97	116
150	188	276	98	128	173	167	181	199	147	167	197	75	106	128	156	176	204
113	170	255	101	166	200	161	174	198	96	124	155	79	111	153	*	*	*
148	194	239	101	164	223	115	184	265	108	141	200	86	121	219	94	134	172
144	191	280	118	145	173	103	145	174	88	128	167	75	94	121	158	158	158
162	233	314	115	152	240	170	184	192	105	133	160	86	115	138	171	191	211
102	195	363	100	167	262	98	185	303	84	137	238	62	109	240	72	127	240
102	195	363	96	162	269	98	183	330	71	138	273	62	117	254	70	134	240